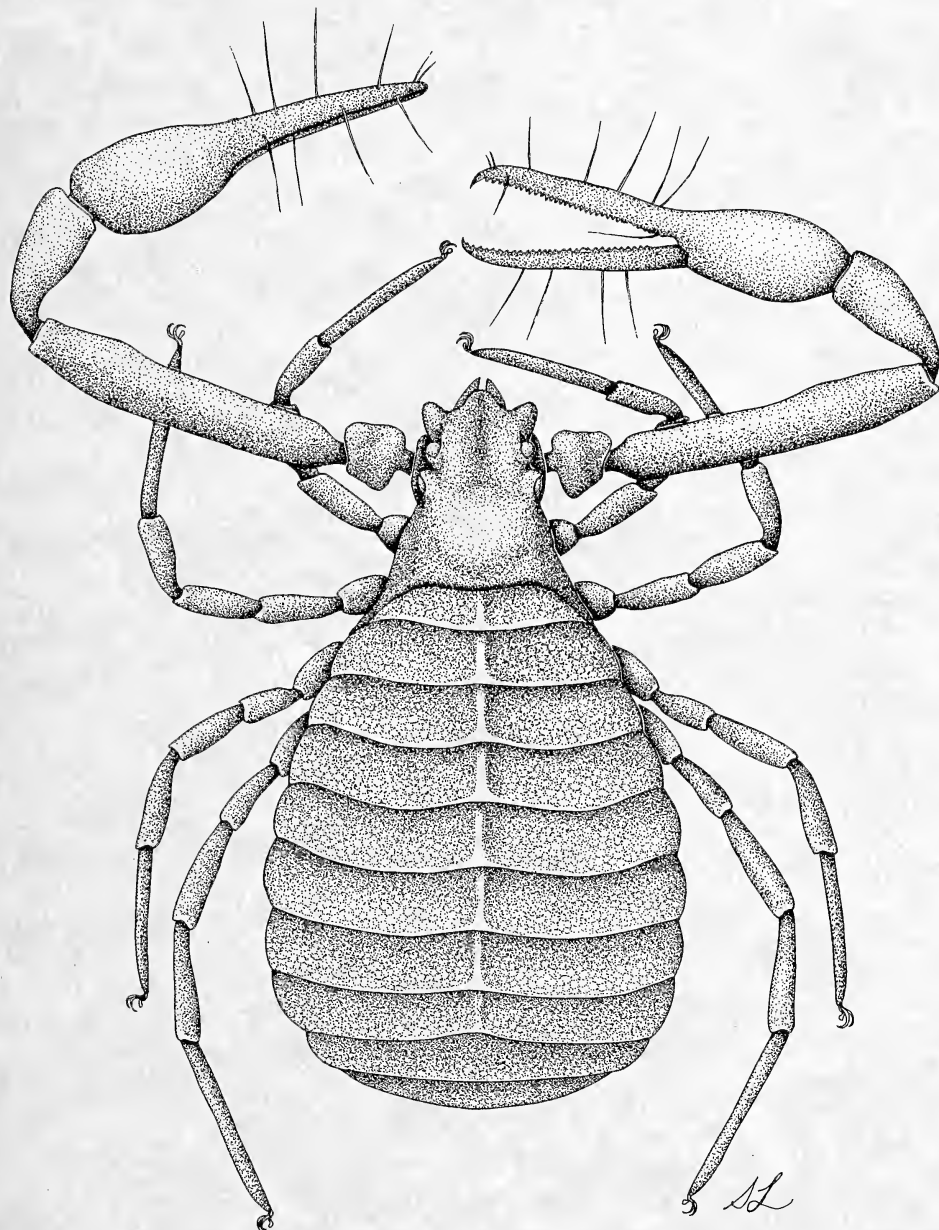


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The Journal of ARACHNOLOGY

OFFICIAL ORGAN OF THE AMERICAN ARACHNOLOGICAL SOCIETY



VOLUME 5

WINTER 1977

NUMBER 1

THE JOURNAL OF ARACHNOLOGY

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SPIDERS OF THE GENUS *PIRATA* IN NORTH AMERICA,
CENTRAL AMERICA AND THE WEST INDIES
(ARANEAE: LYCOSIDAE)

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¹ Mrs. Don L. Frizzell, deceased

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ABSTRACT

Thirty-two species of *Pirata*, including nine new species, from North and Central America and the West Indies are described and illustrated with photographs on 39 plates. Keys to males and females are included. Data on distribution, life history, and ecology are summarized. Photographs of all available types are included.

INTRODUCTION

Wolf spiders of the genus *Pirata* have been recorded from all the continents and many islands. In the area covered by this study most of them are small with a body length of a centimeter or less and are easily overlooked by collectors or passed up as immatures. The object of this study was to describe all of the species known from North and Central America and the West Indies. No attempt was made to determine the limits of the genus; this would require a study on a much wider basis. We have followed Chamberlin, Gertsch, Kaston and others in recognizing *Pirata* as those species that have a tuning-fork pattern on the carapace, plus a few others, one or two of doubtful affinity. The genitalia of the species included in this study differ enough to suggest that several lines of descent are involved and that they will fall into several genera when the family has been studied thoroughly.

Members of *Pirata* occur typically around bodies of water, upon which they run with great ease, or in bogs, swamps and marshes. Several species may be found in damp meadows or on mesic slopes. One species was collected originally in Florida in a rotten log in a mesic hammock.

The cocoon is carried around attached to the spinnerets. This behavior makes these little spiders much more conspicuous to the eyes of the collector than is usually the case.

As early as 1963 Harriet Exline wrote to Wallace that she was beginning a study of the genus *Pirata* and during the next five years they exchanged specimens and information at infrequent intervals. Shortly after Harriet's death in 1968 Dr. William B. Peck, who had been intrusted with her collection and spider papers, wrote to Wallace and inquired if he would be interested in finishing her manuscript on *Pirata*. Wallace replied in the affirmative and shortly thereafter received the manuscript and began to study the collections. It soon became obvious that Miss Exline had studied all of the larger collections except the Chamberlin collection and Wallace was pleased to note that they agreed on every identification except in two or three cases where it appeared she had put a wrong label in a vial with species with which she was perfectly familiar.

As the work progressed Wallace recorded on 3×5 cards all of the data available on every specimen examined and it finally appeared to him that it would be simpler in writing up the results of the study to start from scratch in describing the species and to use his 3×5 cards in compiling the data on distribution, life history and ecology. As a result, only the specimens examined by Wallace are recorded in this study (those examined by Miss Exline would be included). Records from the literature are not included. In fairness to Miss Exline it should be pointed out that any mistakes or faulty judgements in this paper are attributable to Wallace and not to her.

During this investigation Wallace found photographs of the genitalia and, indeed, of the whole spider, to be very useful in studying diagnostic characters and in comparing species. As he progressed from one species to the next it was very convenient and necessary to compare photographs dozens of times and often this made it unnecessary to locate a vial and remove specimens for study under a microscope. Photographs are used to illustrate this paper because, even though the picture may not be as good as one might wish for, still it is a more accurate representation of the structure than Wallace could have made in a drawing. The small size of the genitalia in *Pirata* often makes securing a good photograph almost impossible. Nevertheless, the characteristics necessary to distinguish between species can be illustrated on film.

SYNONYMS

- **Pirata agilis* Banks, 1892 = *P. montanus* Emerton
- **Pirata arenicola* Emerton, 1909, female = *P. piraticus* (Clerck)
- **Pirata arenicola* Emerton, 1909, male = *P. aspirans* Chamberlin
- Pirata californicus* Banks, 1904 = *P. sedentarius* Montgomery
- **Pirata elegans* Stone, 1890 = *P. montanus* Emerton
- **Pirata exigua* Banks, 1892 = *P. minutus* Emerton
- Pirata febriculosa* Becker, 1881 = *P. piraticus* (Clerck)
- **Pirata humicolus* Montgomery, 1902 = *P. minutus* Emerton
- **Pirata liber* Montgomery, 1902 = *P. insularis* Emerton
- **Pirata loennbergi* Tullgren, 1901 = *Sosippus floridanus* Simon
- **Pirata nigromaculatus* Montgomery, 1904 = *P. montanus* Emerton

Pirata piraticus Emerton, 1885 = *P. marxi* Stone

Pirata procursus Montgomery, 1902 = *Pardosa xerampelina* (Keyserling)

Pirata prodigiosa Keyserling, 1876 = *P. piraticus* (Clerck)

**Pirata sylvestris* Emerton, 1909, female = *P. piraticus* (Clerck)

**Pirata sylvestris* Emerton, 1909, male = *P. insularis* Emerton

**Pirata transversolineatus* Tullgren, 1901 = *Sosippus floridanus* Simon

**Pirata wacondana* Scheffer, 1904 = *P. sedentarius* Montgomery

*Type examined by H. K. Wallace.

METHODS

All of the descriptions and measurements in this paper are of specimens preserved in ethyl or isopropyl alcohol (we use 70%). The measurements were made with an ocular micrometer in a Leitz stereoscopic microscope. All data on every specimen examined are recorded by species on printed 3 × 5 data cards which will be deposited in the Florida State Collection of Arthropods, Division of Plant Industry, University of Florida, Gainesville, Florida. These cards could be useful to students wishing to make life history or distributional studies. More than three thousand photographs were taken; these will be deposited with the 3 × 5 cards. Collection of adult males and females, egg sacs, and penultimate males was tallied by species for each month of the year and the distribution of each species plotted on an outline map of North America. This information is summarized in the treatment of each species.

A large number of hours were spent trying to work out a system of numbering and locating the ventral spines on legs I and II that could be used in distinguishing between species with unsatisfactory results.

INTRODUCTION TO THE KEYS

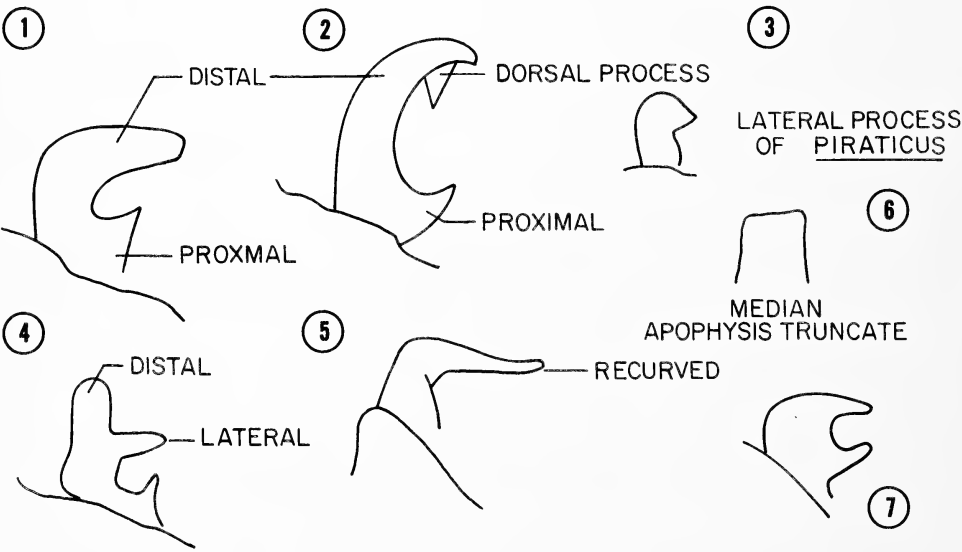
Some of the characters in the keys are based upon average specimens. For example, with respect to the markings on the carapace: the tuning-fork pattern may be distinct or broken up into pigmented spots in different individuals of the same species—these are keyed as having a tuning-fork mark; the amount of pigment varies so that the carapace in normally pigmented specimens appears to have a submarginal light stripe with pigmented margin, while lightly pigmented specimens appear to have a wide marginal light band and heavily pigmented specimens no light band at all—these may be keyed both with a submarginal light band and a marginal light band. In some species the annulae on the legs vary from distinct to very faint. These are keyed as with annulae.

KEY TO MALE *PIRATA*

- 1a. Tibia I with eight or fewer long overlapping ventral spines 2
- 1b. Tibia I with more than eight long overlapping ventral spines *spiniger*
- 2a(1a). Tibia I distinctly swollen, metatarsus I with a distinct brush of hairs on ventral surface *cantralli*, n. sp.

2b.	Tibia I not swollen, metatarsus I without brush	3
3a(2b).	Carapace dark, heavily pigmented without tuning-fork mark or lateral light stripes	4
3b.	Carapace with tuning-fork pattern or head region unpigmented	7
4a(3a).	Lower margin of furrow of chelicerae with two teeth, femur I quite dark; carapace 1.7 mm long or less	<i>minutus</i>
4b.	Lower margin of furrow of chelicerae with three teeth, (lateral tooth may be quite small); carapace more than 1.7 mm long	5
5a(4b).	Anterior eye row strongly procurved; femur, patella and tibia I dark .	<i>bryantae</i>
5b.	Anterior eye row weakly procurved or straight; femur I light or banded; tibia I not dark	6
6a(5b).	Median apophysis of palpus small, chunky, terminating in a sharp point, without a proximal process (Fig. 3)	<i>piraticus</i>
6b.	Median apophysis larger, distal process forms almost a right angel with base, ending in a rounded tip; with a proximal process (Fig. 1)	<i>sedentarius</i>
7a(3b).	Lower margin of furrow of chelicerae with two teeth	8
7b.	Lower margin of furrow of chelicerae with three teeth (sometimes lateral tooth is quite small)	10
8a(7a).	Carapace 3.0 mm long or more	<i>marxi</i>
8b.	Carapace less than 2.0 mm long	9
9a(8b).	Femur I dark, sides of carapace dark, legs not banded	<i>minutus</i>
9b.	Femur I light or banded; carapace with a wide marginal light area .	50
10a(7b).	Sides of carapace dark, without lateral light area	11
10b.	Sides of carapace with lateral light area	13
11a(10a).	Median apophysis of palpus with long distal or lateral process	12
11b.	Distal process of median apophysis broadly truncate, with rounded distal edge (Figs. 6, 228)	<i>montanus</i>
12a(11b).	Carapace less than 1.8 mm long, femur I dark; distal process of median apophysis forms an arc with base which has another, pointed proximal process (Fig. 2)	<i>minutus</i>
12b.	Carapace more than 1.8 mm long; femur I not much darker than other leg segments; distal process of median apophysis forms an angle with base; tip of distal process recurved somewhat; base of median apophysis with a rounded proximal process (Fig. 5)	<i>pagicola</i>
13a(10b).	Sides of carapace with a wide marginal light area, with or without pigmented rim	14

13b.	Sides of carapace with a distinct submarginal light area separated from rim by conspicuous band or areas of pigment	32
14a(13a).	Femur I dark	<i>hiteorum</i> , n. sp.
14b.	Femur I light or banded or not much darker than other leg segments	15
15a(14b).	Carapace less than 2.0 mm long	16
15b.	Carapace 2.0 mm long or longer	27
16a(15a).	Anterior eye row as wide as posterior medium row, straight	<i>seminola</i>
16b.	Anterior eye row narrower than posterior median row	17
17a(16b).	Distal process of median apophysis truncate, not pointed or rounded	18
17b.	Distal process pointed or rounded	19
18a(17a).	Distal process short, truncate (Fig. 6); anterior eye row procurved and much narrower than posterior median row	<i>hiteorum</i> , n. sp.
18b.	Distal process elongate, hatchet-shaped; femur I light or banded; anterior eye row straight or only slightly procurved	<i>alachuus</i>
19a(17b).	Distal process almost as short as proximal process so that median apophysis is robust, but small and chelate in appearance (Fig. 7)	<i>suwaneus</i>
19b.	Median apophysis not chelate in appearance	20



Figs. 1-7.—Explanation of key to the males. For key purposes there is no lateral process unless a distal process is present also, except in the case of *P. triens*, which appears to be of the *P. aspirans* type, and *P. piraticus*. Median apophysis: 1, *P. sedentarius*, *P. seminola*, *P. veracruzae*; 2, *P. insularis*, *P. minutus*; 3, *P. piraticus*; 4, *P. aspirans*, *P. triens*, *P. iviei*; 5, *P. mayaca*, *P. pagicola* (median apophysis recurved); 6, *P. montanus*, *P. hiteorum* (median apophysis truncate); 7, *P. suwaneus*.

20a(19b). Apex of distal process of median apophysis pointed, without an egg-tooth-like structure on tip 21

20b. Apex of distal process rounded, with an egg-tooth-like structure on tip 23

21a(20a). Median apophysis with a distinct proximal process 22

21b. Median apophysis without a distinct proximal process (Fig. 183) *davisi*, n. sp.

22a(21a). Median apophysis viewed from beneath with a curved distal process, the tip of which is spatulate in lateral view *nanatus*

22b. Median apophysis viewed from beneath with a distal process that has a straight distal edge then angles sharply to apex; not spatulate in lateral view 30

23a(20a). Anterior median eyes twice as large as laterals 24

23b. Anterior median eyes not much larger than anterior laterals 25

24a(23a). Median apophysis with a large, plate-like circular distal process continuous with a short lateral process *iviei*, n. sp.

24b. Median apophysis with a finger-like distal process rather than a plate-like one with a proximal process *allapahae*

25a(23b). Distal process, in ventral view, forms almost a right angle with body of median apophysis 26

25b. Distal process in ventral view evenly curved or forms only a slight angle with body of median apophysis; tip round, usually lighter in color than rest of median apophysis *apalacheus*

26a(25a). Tip of distal process of median apophysis round; without egg-tooth-like process; proximal process not pointed *welakae*, n. sp.

26b. Tip of distal process pointed or with egg-tooth-like process; proximal process pointed 54

27a(15b). Median apophysis short, chunky, with a short pointed lateral process and no distal process which gives whole median apophysis the silhouette of the head of a bird with a short beak (Fig. 3) *piraticus*

27b. Median apophysis with distal or lateral process or both, not short or chunky 28

28a(27b). Median apophysis with both distal and lateral process 53

28b. Median apophysis with distal or lateral process, but not both 29

29a(28b). With distal process and no lateral process 31

29b. Median apophysis without distal process and with a very much enlarged lateral process, spatulate at tip (Fig. 75) *triens*, n. sp.

30a(22b). Distal arm narrower than body of median apophysis and forming a right angle with it; cymbium 0.49 mm long *turrialbicus*, n. sp.

- 30b. Distal arm as wide or wider than body and forming less than a right angle with it; cymbium 0.59 mm long *felix*
- 31a(29a). Tip of Distal arm at median apophysis truncate, hatchet-shaped *alachuus*
- 31b. Tip of distal arm not truncate or hatchet-shaped 45
- 32a(13b). Carapace 2.9 mm or less long 34
- 32b. Carapace 3.0 mm or more long 33
- 33a(32b). Lower margin of furrow of chelicerae with two teeth; median apophysis very large (Fig. 201) *marxi*
- 33b. Lower margin with three teeth *sedentarius*
- 34a(32a). Anterior eye row straight or only slightly procurved 36
- 34b. Anterior eye row distinctly procurved 35
- 35a(34b). Median apophysis small, chelate, the distal and basal processes almost same length (Figs. 7, 126-127) *suwaneus*
- 35b. Median apophysis with long, robust distal process with tip round and normally lighter in color than body *apalacheus*
- 36a(34a). Carapace 1.9 mm or less long 37
- 36b. Carapace 2.0 mm or more long 42
- 37a(36a). Anterior eye row straight and as wide or almost as wide as posterior median row *seminola*
- 37b. Anterior eye row slightly procurved; narrower than posterior median row . . 38
- 38a(37b). Median apophysis with long, curved distal process bearing dorsal process near its tip; with a short basal process (Fig. 2) *insularis*
- 38b. Not so 39
- 39a(38b). Median apophysis with a finger-like lateral process and a flat, round plate-like distal process *iviei*, n. sp.
- 39b. Median apophysis with a lateral or distal process, but not both 40
- 40a(39b). Distal process forms almost a right angle with the body of the median apophysis and is drawn out into a long recurved tip (Figs. 5, 92) *mayaca*
- 40b. Distal process forms almost a right angle with body of median apophysis, but is shorter, thicker and not recurved 41
- 41a(40b). Distal process curved and gradually narrows to a point in ventral view; spatulate in lateral view; lacks proximal process. ARE=PME; anterior eye row straight *seminola*
- 41b. Distal process more angular and wider, often with what looks like a small egg-tooth on tip; not spatulate in lateral view; with a proximal process. ARE narrower than PMR *allapahae*, *sedentarius*, *veracruzae*

- 42a(36b). With a brush at hair-like structures on metatarsus I, tibia I and II swollen *cantralli*, n. sp.
- 42b. Metatarsus I without brush; tibia I and II not swollen 43
- 43a(42b). Median apophysis with well developed distal or lateral process, or both . . . 44
- 43b. Distal process not developed, median apophysis small, similar to that of *P. piraticus*, but with a rounded tip instead of a pointed tip like that of *P. piraticus* (Fig. 3) *zelotes*, n. sp.
- 44a(43a). Median apophysis with well developed distal and lateral process *aspirans*
- 44b. With distal process well developed, but no lateral process 47
- 45a(31b). Distal process of median apophysis robust, gently curved; of *insularis* type, without lateral process, with small proximal process; carapace 2.9 mm long or longer *giganteus*
- 45b. Distal process not robust, forms an angle with body of median apophysis . . 46
- 46a(45b). Distal process long, drawn out into a slender, recurved tip (Fig. 5) . . . *pagicola*
- 46b. Distal process not recurved 52
- 47a(44b). Median apophysis with a long evenly curved distal process which bears a dorsal process near its tip 51
- 47b. Distal process forms almost a right angle with body of median apophysis and lacks a dorsal process 48
- 48a(47b). Distal process long, drawn out into a slender, recurved tip (Figs. 5, 102, 104) *pagicola*
- 48b. Distal process short, not recurved, with an egg-tooth-like process on tip (Figs. 1, 159-160) *sedentarius*
- 49a(24b). Distal process in ventral view evenly curved; a straight shelf-like structure just proximal of base of median apophysis (Fig. 235) *sylvanus*
- 49b. Distal process slightly angled, its tip rather short, round, and usually lighter in color than rest of median apophysis *apalacheus*
- 50a(9b). Distal process long, attenuated, forming less than a right angle with body of median apophysis *montanoides*
- 50b. Distal process short, wide, forming almost a right angle with body of median apophysis *turrialbicus*, n. sp.
- 51a(47a). Median apophysis with a proximal process, distal process not spatulate in lateral view, bearing a pointed distal process (Figs. 2, 84, 88) *insularis*
- 51b. Median apophysis without a proximal process; distal process spatulate in lateral view, dorsal process not pointed—shelf-like *seminola*
- 52a(46b). Distal process forms almost a right angle with body of median apophysis; is short and may have an egg-tooth-like process at tip (Figs. 1, 159-160) *sedentarius*

- 52b. Distal process more elongate; does not form a right angle with body of median apophysis; most significant feature is a straight, shelf-like structure proximal to and ventral to body of median apophysis (Fig. 235) *sylvanus*
- 53a(28a). Median apophysis with a large, plate-like circular distal process that is continuous with a short lateral process *iviei*, n. sp.
- 53b. Distal process at median apophysis as long as lateral process, not circular and plate-like *aspirans*
- 54a(26b). Anterior edge of distal process of median apophysis slightly arched; tip ending in egg-tooth-like process *sedentarius*
- 54b. Anterior edge of distal process straight, sharply angled to form tip *turrialbicus*, n. sp.

KEY TO FEMALE *PIRATA*

- 1a. Tibia I with eight or fewer long overlapping ventral spines 2
- 1b. Tibia I with more than eight long overlapping ventral spines *spiniger*
- 2a(1a). Carapace dark, heavily pigmented, without tuning-fork mark or lateral light stripes *bryantae*
- 2b. Carapace with tuning-fork pattern or head region unpigmented 3
- 3a(2b). Sides of carapace dark, without a marginal or submarginal light area 4
- 3b. With a marginal or submarginal light band on both sides of carapace 5
- 4a(3a). Retromargin or furrow of chelicerae with three teeth; carapace 2.0 mm long or longer 36
- 4b. Retromargin with two teeth; carapace less than 2.0 mm long *minutus*
- 5a(3b). Retromargin of chelicerae with two teeth 6
- 5b. Retromargin with three teeth (tooth next to base of fang may be so small it is difficult to see) 7
- 6a(5a). Carapace 3.0 mm long or longer *marxi*
- 6b. Carapace less than 3.0 mm long *pagicola*
- 7a(5b). Carapace with a wide marginal light band with or without pigmented rim 8
- 7b. Carapace with a submarginal light area, separated from rim by a distinct band of pigment which may or may not be continuous 26
- 8a(7a). Epigynum has two lobes which extend posteriorly beyond epigastric furrow. . 9
- 8b. Epigynal lobes do not extend posteriorly beyond epigastric furrow 20

9a(8a). Epigynal lobes somewhat pointed posteriorly (Fig. 9) 10

9b. Epigynal lobes rounded posteriorly (Fig. 8) 16

10a(9a). Epigynal lobes concave on postmedial surface 11

10b. Not so 15

11a(10a). Epigynal lobes contiguous 12

11b. Not so 13

12a(11a). Carapace less than 2.0 mm long; legs without annulae; seminal receptacles converge anteriorly; anterior median eye diameter double that of anterior lateral eye diameter *allapahae*

12b. Carapace 2.0 mm long or longer; legs with annulae; seminal receptacles parallel or diverge anteriorly; anterior median eyes less than twice diameter of anterior lateral eyes *aspirans*

13a(11b). Carapace more than 2.5 mm long; dorsum with prominent white paired spots; seminal receptacle openings on ventral surface, middle of lobes halfway back *piraticus*

13b. Carapace less than 2.5 mm long 14

14a(13a). Epigynum of *aspirans* type (Fig. 10) with ventral overhang forming a kind of cave-like entrance posteriorly; carapace less than 2.0 mm long *iviei*, n. sp.

14b. Epigynum consists of two prominent lobes projecting posteriorly without ventral overhand characteristic of *aspirans* group 32

15a(10b). Lobes of epigynum almost contiguous, separated by less than width of a lobe (U.S.A.) (Figs. 197-198) *hiteorum*, n. sp.

15b. Lobes of epigynum well separated, by at least width of a lobe (Costa Rica) (Figs. 109, 118) 34

16a(9b). Carapace more than 2.0 mm long *sedentarius*

16b. Carapace less than 2.0 mm long 17

17a(16b). Lobes of epigynum concave on posteromedial surface 19

17b. Not so 18

18a(17b). Lobes of epigynum contiguous posteriorly 36

18b. Lobes of epigynum separated by almost width of a lobe *welakae*, n. sp.

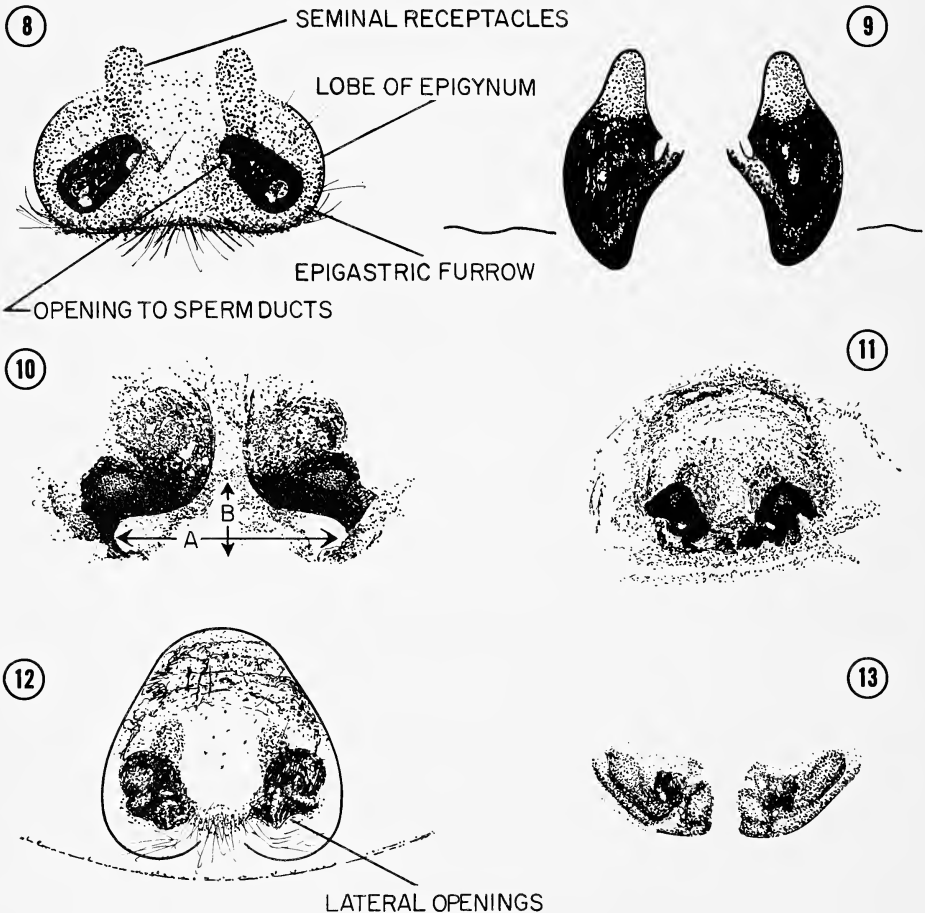
19a(17a). Seminal receptacles diverge anteriorly at an angle of about 90 degrees *nanatus*

19b. Seminal receptacles almost parallel to each other or converge anteriorly . . . 37

20a(8b). Carapace more than 2.4 mm long; epigynum consists of two large, almost circular, heavily pigmented contiguous plates *giganteus*

20b. Carapace less than 2.4 mm long 21

- 21a(20b). Epigynal lobes of *aspirans* type (concave on posteromedial surface)22
 21b. Epigynal lobes not concave on posteromedial surface24
- 22a(21a). Carapace less than 2.0 mm long38
 22b. Carapace 2.0 mm or more long (Great Lakes region)23
- 23a(22b). Anterior median eyes twice as large as anterior laterals; epigynal opening (Fig. 10) A/B=4/1*indigenus*, n. sp.
 23b. Anterior median eyes less than twice as large as laterals; epigynal opening (Fig. 10) A/B=2/1*triens*, n. sp.



Figs. 8-13.—Explanation of key to the females. Epigynum: 8, *P. alachuus*. Seminal receptacles parallel, lobes do not extend posterior to epigastric furrow, lobes rounded posteriorly, openings to sperm ducts on posteroventromedial surface of lobes of the epigynum, lobes of epigynum contiguous; 9, *suwaneus* type. Lobes extend posterior to epigastric furrow, lobes pointed posteriorly, lobes concave on posteromedial surface; 10, *aspirans* type. A, width of epigynal opening, B, length of epigynal opening; 11, *P. montanoides*. Epigynum not divided into right and left lobes. Pigmented areas look like clipped ears of a dog; 12, *P. sylvanus*. Epigynal openings lateral in position; 13, *P. zelotes*, n. sp. Epigynal lobes shaped like human ears.

- 24a(21b). Epigynal openings on posterior edge of lobes facing posterolaterally (Figs. 11-12) 25
- 24b. Epigynal openings on ventral surface of lobes and central located . . . *alachuus*
- 25a(24a). Heavily sclerotized portions of epigynum doughnut-shaped with light center (Fig. 12) *sylvanus*
- 25b. Heavily sclerotized portions of epigynum shaped like trimmed ears of a dog (Fig. 11) *montanoides*
- 26a(7b). Carapace 3.0 mm long or longer; epigynal lobes shaped somewhat like human ears (Fig. 13) *zelotes*, n. sp.
- 26b. Carapace less than 2.0 mm long 27
- 27a(26b). Epigynal lobes rounded posteriorly 28
- 27b. Epigynal lobes pointed posteriorly 30
- 28a(27a). Epigynal lobes concave on posteromedial surface 29
- 28b. Epigynal lobes not concave 31
- 29a(28a). Epigynal lobes contiguous; anterior median eyes double that of anterior lateral eyes; seminal receptacle openings on inner edge of lobes halfway back. *mayaca*
- 29b. Epigynal lobes not contiguous; anterior median eyes less than double that of anterior lateral eyes; seminal receptacle openings ventral surface middle of lobe, halfway back 33
- 30a(27b). Carapace less than 2.0 mm long 39
- 30b. Carapace 2.0 mm long or longer *pagicola*, *mayaca*
- 31a(28b). Carapace less than 2.2 mm long *seminola*
- 31b. Carapace 2.2 mm long or longer *insularis*, *cantralli*, n. sp.
- 32a(14b). Seminal receptacles converge anteriorly (Florida) *allapahae*
- 32b. Seminal receptacles parallel or diverge anteriorly (Central America) 34
- 33a(29b). Carapace less than 2.5 mm long; seminal receptacle openings on ventral surface in middle of lobe, halfway back *seminola*
- 33b. Carapace usually more than 2.2 mm long; seminal receptacle openings on posteromedial surface of lobe of epigynum *sedentarius*
- 34a(15b,32b). Apex of lobes of epigynum pointed; carapace 1.7 mm long *turrialbicus*, n. sp.
- 34b. Apex of lobes curved rather than pointed; carapace 1.9-2.1 mm long . . . *felix*
- 35a(4a). With *aspirans* type epigynum, i.e., lobes extending posterior to epigastric furrow, somewhat pointed, concave on posteromedial aspect (Figs. 98-99, 103) *pagicola*
- 35b. Epigynum without posteriorly projecting lobes (Fig. 229) *montanus*

- 36a(18a). Lobes of epigynum large, round, heavily sclerotized; may look like two round black plates *apalacheus*
- 36b. Not so 40
- 37a(19b). Anterior eye row almost straight; anterior median eyes twice as large as laterals *allapahae*
- 37b. Anterior eye row distinctly procurved; anterior median eyes not much larger than anterior laterals *welakae*, n. sp.
- 38a(22a). Epigynal opening three times as wide as long (Fig. 10-A/B) (Georgia, North Carolina) *iviei*, n. sp.
- 38b. Epigynal opening four times as wide as long (Fig. 10-A/B) (Texas, Mexico) *davisi*
- 39a(30a). Epigynum of *aspirans* type (Fig. 10) with deep concavities on posteromedial aspect of each lobe *iviei*, n. sp., *pagicola*, *mayaca*
- 39b. Epigynum of *suwaneus* type (Fig. 9), somewhat concave on posteromedial aspect of each lobe, but not excavated as in *aspirans* type . . *suwaneus*, *browni*
- 40a(36b). Lobes of epigynum round posteriorly, weakly developed *alachuus*
- 40b. Lobes of epigynum pointed posteriorly, concave on posteromedial aspect (*aspirans* type) *pagicola*

SPECIES GROUPS

In the descriptions species that appear to be most closely related are arranged in groups. In the last group species whose relationships are uncertain are treated in alphabetical order. The following is a list of the groups and their included species.

(1) *nanatus* group: *P. allapahae* Gertsch, *P. apalacheus* Gertsch, *P. nanatus* Gertsch, *P. seminola* Gertsch and Wallace, *P. welakae*, n. sp.

(2) *aspirans* group: *P. aspirans* Chamberlin, *P. indigenus*, n. sp., *P. iviei*, n. sp., *P. triens*, n. sp.

(3) *insularis* group: *P. insularis* Emerton, *P. cantralli*, n. sp.

(4) *mayaca* group: *P. mayaca* Gertsch, *P. pagicola* Chamberlin.

(5) *felix* group: *P. felix* Pickard-Cambridge, *P. browni* Gertsch and Davis, *P. suwaneus* Gertsch, *P. turrialbicus*, n. sp., *P. veracruzae* Gertsch and Davis.

(6) *piraticus* group: *P. piraticus* (Clerck), *P. zelotes*, n. sp.

(7) *sedentarius* group: *P. sedentarius* Montgomery, *P. spiniger* (Simon).

(8) Species of uncertain relationship: *P.alachuus* Gertsch and Wallace, *P. bryantae* Kurata, *P. davisi*, n. sp., *P. giganteus* Gertsch, *P. hiteorum*, n. sp., *P. marxi* Stone, *P. minutus* Emerton, *P. montanoides* Banks, *P. montanus* Emerton, *P. sylvanus* Chamberlin and Ivie.

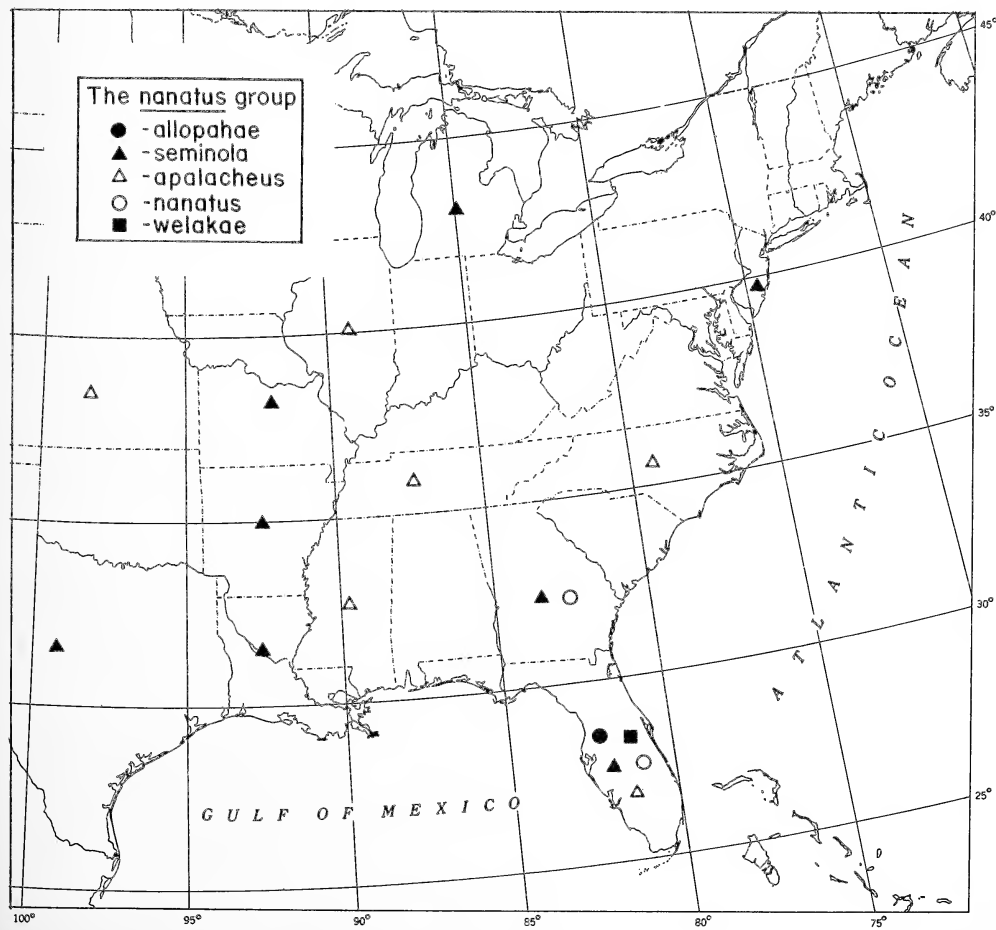
In listing the specimens examined locality, date, collector, etc., usually are given for species known from only a few localities. In cases where the species is represented by numerous collections only state and county are given. The abbreviations in parentheses following the number of specimens indicates the collection in which the vial is deposited.

Dates are given as listed on labels to avoid the possibility of error in conversion to some standard form.

THE NANATUS GROUP

The following five species in the southeastern United States, *P. apalacheus*, *P. nanatus*, *P. seminola*, *P. allapahae*, and *P. welakae*, n. sp., may easily be confused, although they differ in character combinations of size, pattern, spination and structure of the genitalia. *P. nanatus*, *P. apalacheus*, and *P. welakae*, have marginal light areas on the carapace while the other two have submarginal light bands (*P. seminola* has marginal banding in Arkansas). *P. nanatus* and *P. allapahae* epigyna are very similar, but may be distinguished by the position of the seminal receptacles; in the latter they are parallel, in the former they diverge from one another anteriorly. The seminal receptacles also diverge in *P. welakae*, n. sp. The epigynum of *P. nanatus*, *P. allapahae*, and *P. welakae*, n. sp., resemble *P. sedentarius* somewhat, while that of *P. seminola* is very similar in appearance to that of *P. insularis*; and *P. apalacheus* is unique.

The palp of *P. nanatus* is smaller than that of *P. allapahae* (cymbium 0.45 mm versus 0.55 mm) and their median apophyses differ in shape; the median apophysis of *P. nanatus*



is larger in proportion to the size of the cymbium than it is in *P. allapahae*. In *P. nanatus* the median apophysis extends anteriorly beyond the excavation of the cymbium about one-third the distance to its tip. In *P. allapahae* it barely extends beyond the rim of the excavation. In ventrolateral view the anterior process of the median apophysis of *P. nanatus* is wider and more spatulate than in *P. allapahae*, and in *P. allapahae* it is more rounded and less angular than in *P. nanatus*. The palpal tibia is relatively shorter in *P. nanatus* than in *P. allapahae* and *P. seminola*.

The anterior process of the median apophysis in *P. seminola* is spatulate somewhat like that in *P. nanatus* in ventrolateral view, but the median apophysis lacks the distinct medial process of the base like in *P. nanatus*. The median apophysis of *P. seminola* has a dorsally extending shelf that extends to its tip (Fig. 39).

In *P. welakae*, n. sp., the median apophysis is stout and resembles that of *P. sedentarius* somewhat, lacking the basal median process of *P. nanatus* and *P. allapahae*. It is about the same size as these two, but is smaller than in *P. sedentarius*. The median apophysis of *P. apalacheus* has a characteristic light colored, flattened anterior tip.

Pirata allapahae Gertsch

Figs. 14-19

Pirata allapahae Gertsch, 1940, Florida Entomol., 23(2):23, fig. 9 (male, female, Alachua Co., Fla., A.M.N.H., examined).

Etymology.—This species was named after the Allapaha Indian tribe which lived in Florida.

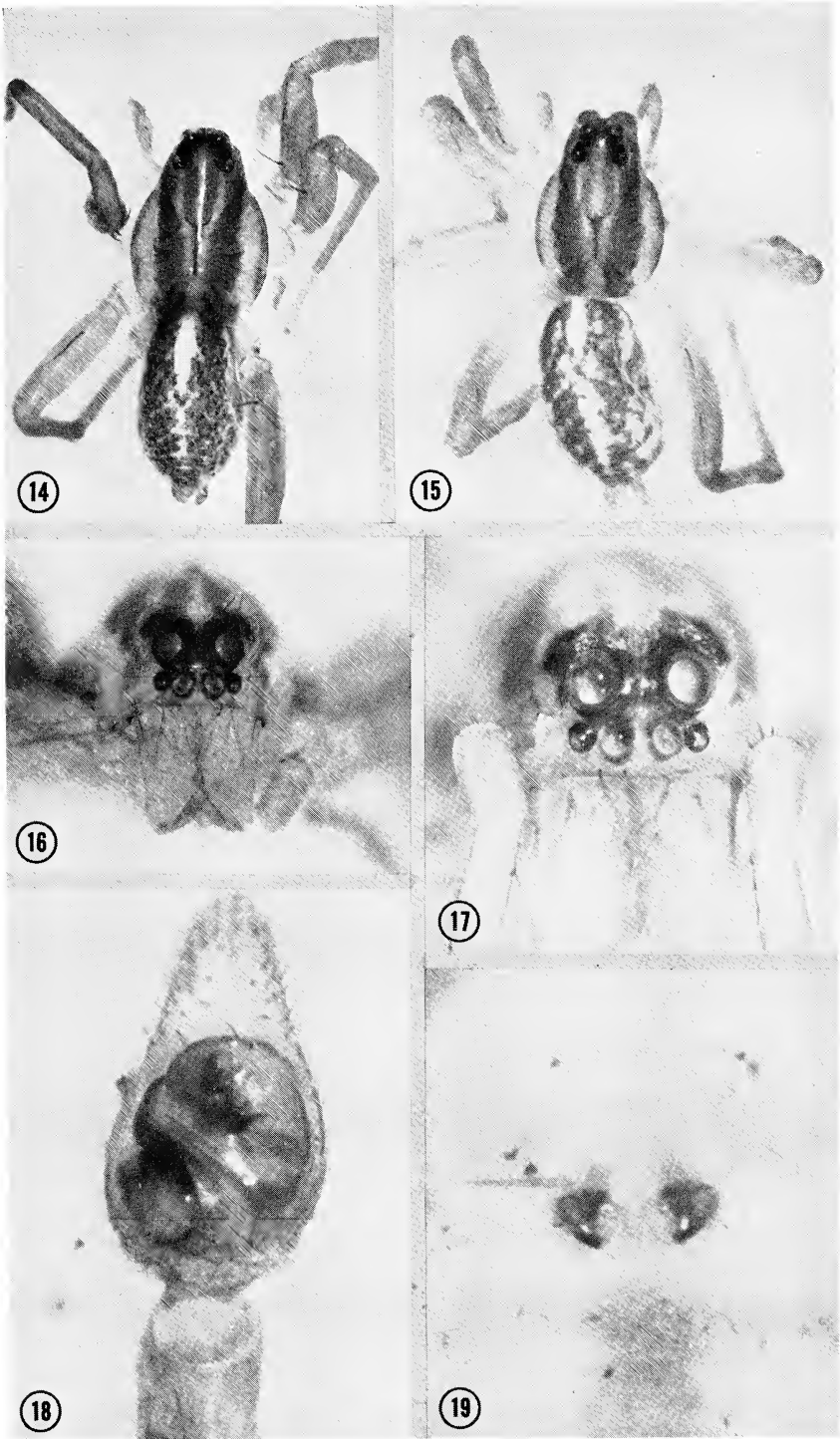
Description of holotype.—A male with carapace 1.75 mm long, 1.25 mm wide. Carapace with a wide submarginal band and typical tuning-fork pattern. Legs dusky, a suggestion of annulae on some femora (Fig. 14). Anterior eye row almost straight, slightly narrower than posterior median eye row; anterior median eyes about twice the size of anterior lateral eyes, anterior eyes evenly spaced. Palpal tibia 0.37 mm, cymbium 0.55 mm long. Median apophysis of palp with a pointed proximal process (Fig. 18).

Description of allotype.—A female with carapace 1.87 mm long, 1.37 mm wide. Carapace with a wide submarginal band, and typical tuning fork pattern. Legs dusky (Fig. 15). Anterior eye row slightly procurved, narrower than posterior median eye row; anterior median eyes are twice as large as the anterior lateral eyes. Epigynum (Fig. 19) with lobes about a diameter apart, concave on medial surface. The seminal receptacles are visible through the body wall; are rather short and inclined towards each other anteriorly. Note: Gertsch did not describe or list a female, but the type vial contains a female labeled as allotype.

Variations and observations.—Gertsch described the pattern of the carapace as having a "broad marginal band and a black edge" which is another way of describing, in our words, "a wide submarginal band." Sometimes the black edge is missing, as in a female from Pasco County, Florida.

In examining the collections we were impressed from time to time with the fact that *P. allapahae* resembled *P. sedentarius* both in pattern and genitalia, although considerably smaller in size.

There is some variation in size. Males range from 1.55 to 1.80 mm in carapace length and females from 1.72 to 2.0 mm.



Figs. 14-19.—*P. allapahae*: 14, holotype male, Florida, Alachua Co.; 15, allotype female, Florida, Alachua Co.; 16, paratype male, eyes, Florida, Alachua Co.; 17, paratype female, eyes, Florida, Alachua Co.; 18, holotype, palpus; 19, allotype, epigynum.

Distribution.—Known only from Florida: Alachua, Lake, Marion, Pasco, and Putnam Counties.

Specimens examined.—*Florida*: Alachua Co.: HKW Sta 7B, Feb. 7, 1937, male holotype, female allotype and male and female paratypes; HKW Cat. No. 1016, Feb. 13, 1938, 1 male; Marion Co.: 9.1 mi. E. Fla. 318 at Citra, N. of Fla. 318, in bog, 13 Apr., 1950, H.G.P. No. 3, male, 6 females, egg sacs (D.P.I.); Pasco Co.: 1.0 mi. S. U.S. 41 x Fla. 52 on U.S. 41, edge cypress bay, March 21, 1947, HKW Cat. No. 1242, female, egg sac (A.M.N.H.); Putnam Co.: U.F.C.R., Mud Springs, K 62, May 3, 1947, HKW Cat. No. 1257, male, female (D.P.I.); U.F.C.R., Margin sawmill pond, G-58, VI.1.47, HKW Cat. No. 1264, 2 males, female (D.P.I.).

Life history.—We have examined males and females collected from February through June; egg sacs from March and April.

Ecology.—This species is apparently not restricted to the edge of water. It has been collected from sphagnum moss around cypress ponds, near a spring on a mesic slope, and under pine needle litter in a flatwoods.

Remarks.—There is some evidence that this species occurs in company with or near to *P. sedentarius* in Florida. *P. allapahae* has paired white spots on the abdomen.

Pirata apalacheus Gertsch

Figs. 20-25

Pirata apalacheus Gertsch, 1940, Florida Entomol., 23(2):17-19, figs. 3, 4 (male, female, Alachua Co., Fla., A.M.N.H., examined); Barnes, 1953, Amer. Mus. Nov., 1632:11.

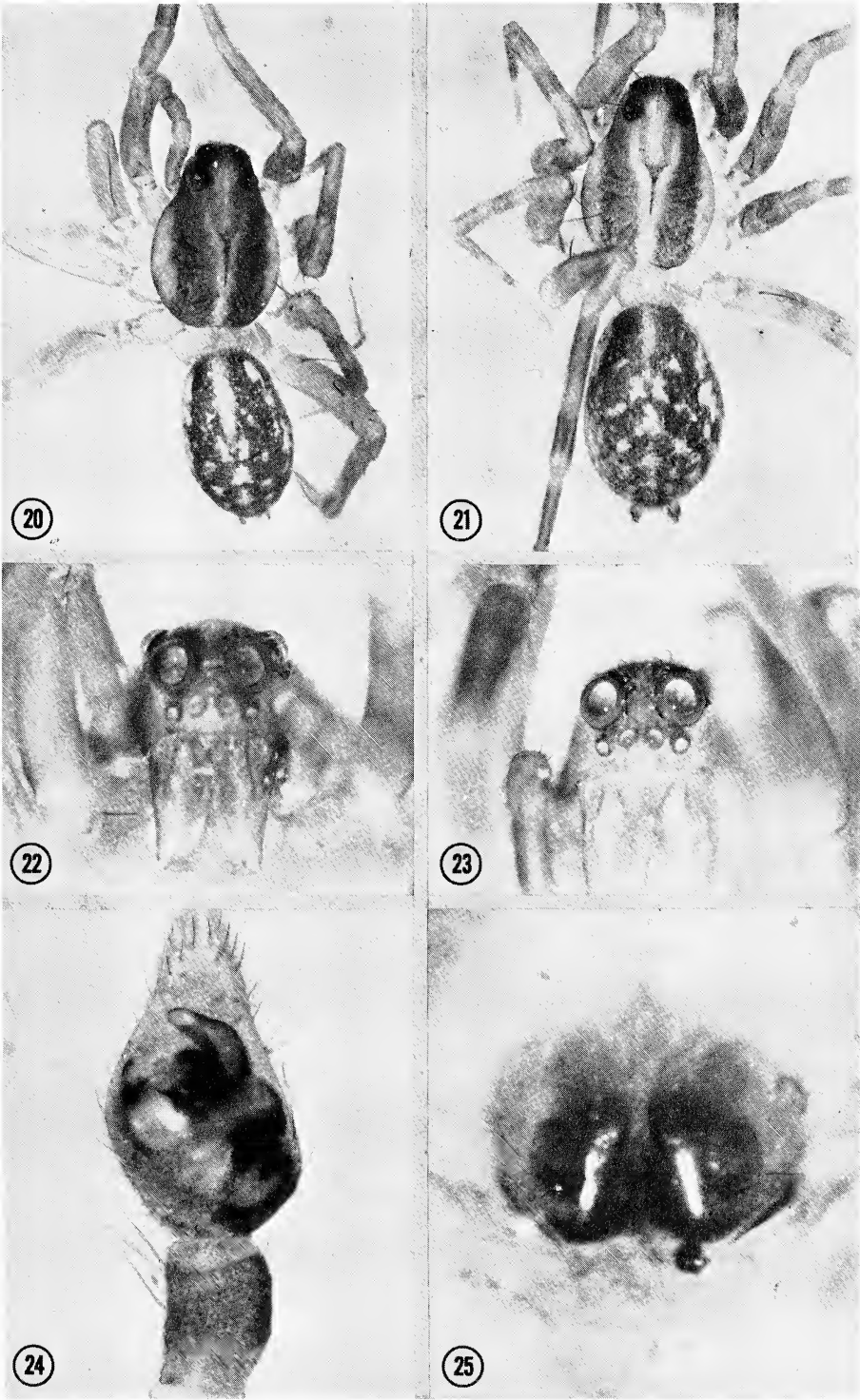
Description of holotype.—Carapace 1.67 mm long, 1.20 mm wide, with a wide marginal light area, narrowly and unevenly pigmented along the edges, the usual tuning-fork mark fading out between the eyes (Fig. 20). Anterior eye row distinctly procurved, much narrower than posterior median eye row, anterior eyes evenly spaced, anterior median eyes about half again as large as anterior lateral eyes (Fig. 22). Height of clypeus is equal to the diameter of an anterior median eye, slanted posteriorly. Legs with indistinct annulae. The median apophysis of palp is quite characteristic in shape with a light-colored tip (Fig. 24).

Description of allotype.—Carapace 1.77 mm long, 1.22 mm wide. Resembles the male except: the tuning-fork mark is quite distinct (Fig. 21); there is very little pigment along edge of carapace, and the clypeus is not slanted as much. The epigynum is quite characteristic in appearance; when heavily pigmented it looks like two black contiguous disks (Fig. 25). Tibia I and II with three pairs of ventral spines, none apical.

Variations and observations.—This species resembles *P. minutus* in appearance and size, but its genitalia are quite different and the front legs are not dark as in the former species. It also resembles *P. welakae* in appearance and size. There is some variation in size, the carapace in males varying in length between 1.5 and 1.7 mm and in females between 1.5 and 1.8 mm.

Distribution.—Southeastern United States, Illinois and Kansas.

Specimens examined.—*Alabama*: Baldwin, Madison, Marshall, Tuscaloosa Counties and Chatahoochie State Park; *Florida*: Alachua, Columbia, Dade, Duval, Jefferson, Highlands, Hillsborough, Indian River, Leon, Liberty, Monroe, Nassau, Polk, Putnam Counties; *Georgia*: Daugherty County; *Illinois*: Madison County, Bell Smith Springs,



Figs. 20-25.—*P. apalacheus*: 20, holotype male, Florida, Alachua Co.; 21, allotype female, Florida, Alachua Co.; 22, holotype male, eyes; 23, allotype female, eyes; 24, holotype, palp; 25, allotype, epigynum.

Bedford; *Kansas*: Douglas County; *Mississippi*: Jackson, Wilkinson Counties; *North Carolina*: Alamance, Carteret, Durham, Orange Counties; *Tennessee*: Roane County.

Life history.—This is evidently a summer species. In Florida males have been taken from April through August and females from March through October with a preponderance in June and July; females with egg sacs have been collected from May through August. From the western and northeastern United States adults have been taken only in July and August. This may be a reflection of collecting activities.

Ecology.—*P. apalacheus* differs from most other species of *Pirata* in its occurrence away from water. The type locality was a rotten log in a mesic hammock far from the nearest pond or stream. H. W. Weems, Jr., collected it in pine needle litter in June in Alachua Co., Florida. H. G. Parrish collected it in leaf litter in a mesic hammock in Alchua Co., Florida. Alan Brady collected it under leaves and logs in Highland Hammock State Park, Florida. At Tall Timbers Research Station in Leon Co., Florida, many collections were made in pitfalls in various types of terrestrial situations away from water, annually burned pine woods, broom sedge-pine, woodyard hammock, beech woods, spruce pine, hickory-sweet gum association, etc. In Everglades Park, Florida, it has been collected in pitfalls in hardwood hammock. It appears to be a humus-loving form.

Pirata nanatus Gertsch

Figs. 26-31

Pirata nanatus Gertsch, 1940, Florida Entomol., 23(2):19-20, fig. 7, 8 (male, female, Turner Co., Ga., A.M.N.H., examined).

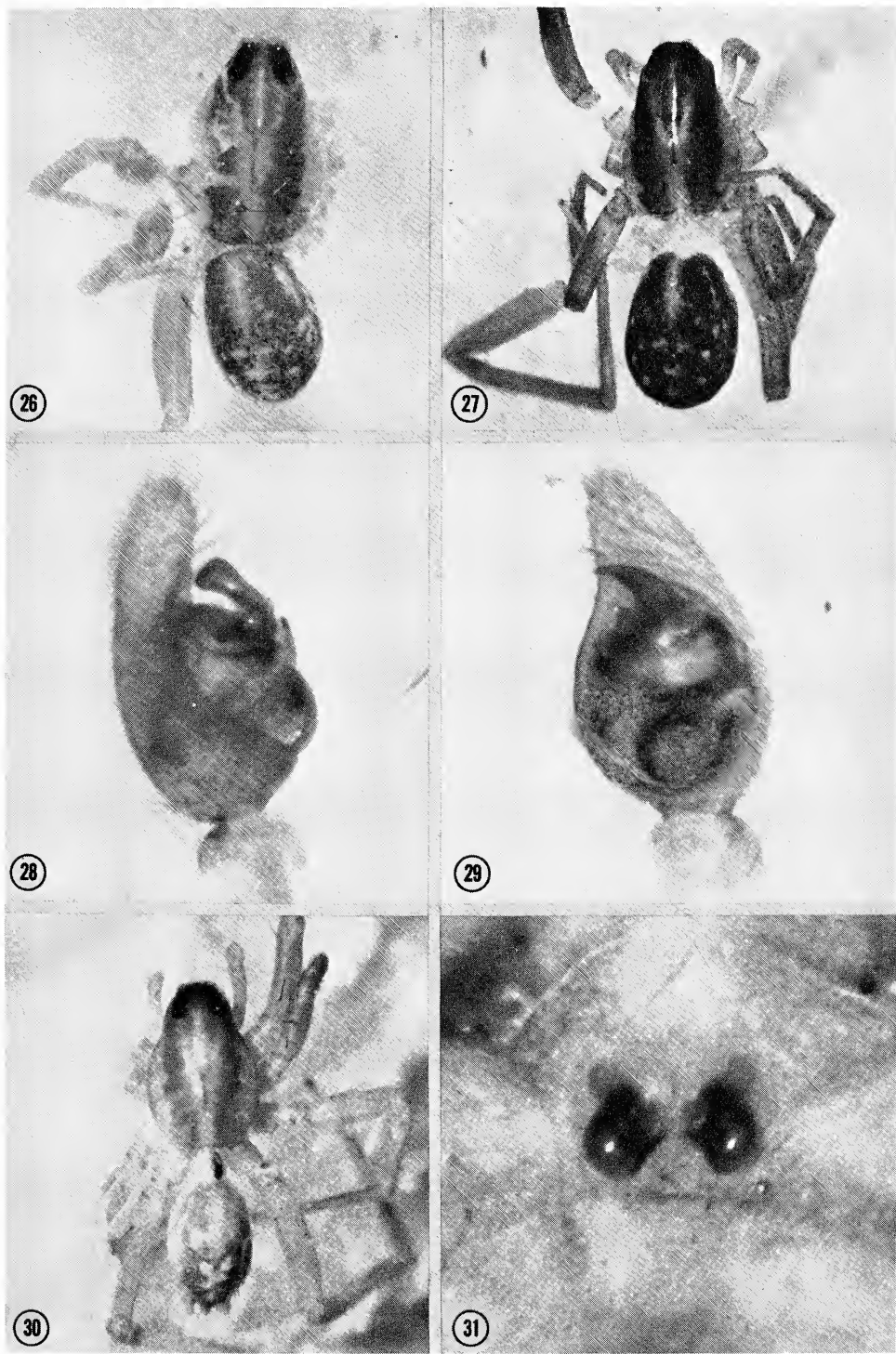
Diagnosis.—*Pirata nanatus* is one of the smallest, if not the smallest *Pirata* in North America. It may easily be confused with *P. seminola*, *P. allapahae* and *P. welakae*, n. sp., all of which occur in the same geographic region. *P. nanatus* has a wide marginal light band on the carapace; in females the epigynum resembles that of *P. sedentarius* and the seminal receptacles diverge anteriorly; the median apophysis of the palp in males extends anteriorly beyond the excavation of the cymbium and has a pointed tooth at its base (Fig. 29).

Descriptive notes on male holotype.—The cephalothorax (Fig. 26) is smashed and five legs and palps are disarticulated. Carapace 1.37 mm long, 1.05 mm wide, with wide marginal light area. Anterior eye row narrower than posterior median eye row, procurved; anterior median eyes larger than anterior lateral eyes, closer to each other than to the laterals. Palpal cymbium 0.45 mm long, palpal tibia 0.25 mm long.

Descriptive notes on female allotype.—Carapace 1.37 mm long, 0.95 mm wide, shiny, with a wide marginal light area (Fig. 27), the "black" edge rather obscure. Eye arrangement similar to that described above for the male.

Descriptive notes on five paratypes.—Two females from Columbia Co., Florida, HKW 402, IV.27.35. These two small females are dark and their patterns are obscure, but appear to have wide marginal light areas; carapaces 1.3 mm long, 0.9 mm wide; most legs disarticulated.

Three females from same collection as holotype, Georgia, Turner Co., 9 mi. S.E. Sycamore, V.6.37, HKW 606 (HKW). Amount of pigment varies somewhat. All three with wide marginal light areas on carapace, carapace shiny, sternum and venter light, legs not banded but are lightly pigmented.



Figs. 26-31.—*P. nanatus*: 26, holotype male, Georgia, Turner Co.; 27, allotype female, Georgia, Turner Co.; 28-29, holotype, palp; 30, male, Georgia, Baker County, Springfield Rd.; 31, allotype, epigynum.

Female No. 1: Carapace 1.30 mm long, 0.95 mm wide. Legs 4123.

Female No. 2: Carapace 1.55 mm long, 1.07 mm wide. Lower margin of furrow of chelicerae with three teeth, middle tooth the largest, tooth next to fang the smallest. Anterior eye row narrower than posterior median eye row, procurved, about equally spaced. Anterior median eyes are one and one-half times as large as the anterior lateral eyes. Legs 4123.

Female No. 3: Carapace 1.25 mm long, 0.88 mm wide. Lower margin of furrow of chelicerae with three teeth, middle tooth the largest, tooth next to the fang the smallest. Eyes like female no. 2. Legs 4123.

Four females from Alachua Co., Florida, have the following dimensions of the carapace: 1.18 mm long, 0.87 wide; 1.27 mm long, 0.95 mm wide; 1.30 mm long, 0.97 mm wide; 1.27 mm long, 0.95 mm wide.

Variation.—*P. nanatus* usually has a wide marginal light area on the carapace; the male from Baker Co., Georgia, has a little pigment along the edge of the carapace. The males we have examined are quite small: carapaces 1.35 mm long, 0.93 mm wide and 1.37 mm long, 1.05 mm wide. The carapace of females varies from 1.18 mm to 1.45 mm in length, with most being less than 1.40 mm.

The spines on tibia I and II are quite long (Fig. 61).

Distribution.—Known only from Florida and Georgia.

Specimens examined.—*Florida*: Alachua Co.: Sta 1 VIC, I.30.37, female paratype (A.M.N.H.); Sta. 1 VIC., IV.19.37, 3 female paratypes (H.K.W.); Columbia Co.: IV.27.35, H.K.W. 402, 2 female paratypes (H.K.W.); Leon Co.: Tall Timbers Research Station, VI.8-14.68, W. H. Whitcomb, male, 3 females (J.A.B.); *Georgia*: Baker Co.: Springfield Pond, 5 July 60, male (H.K.W.); Charlton Co.: Billy's Island, Okefinokee Swamp, W 82° 15': N 30° 45', June, 1912, C. R. Crosby, 7 females (Utah); Turner Co.: 9 mi. S.E. Sycamore, V.6.37, H.K.W. 606, 1 male, 10 females (Holotype, allotype, paratypes, A.M.N.H. and H.K.W.).

Life History.—*P. nanatus* appears to be a spring form judging from the scanty material available. We have examined one male each from May, June and July; one female from January, six from April, ten from May, 16 from June, and one from August. The only egg cases are from May. The scarcity of specimens in collections probably results from their small size and the difficulty of collecting the species.

Ecology.—This species has been collected in flatwoods, sphagnum in flatwoods, near water in a grassy pine woods, on the surface of water in a pond, and from a woodyard hammock (Berlese).

Pirata seminola Gertsch and Wallace

Figs. 32-43

Pirata seminola Gertsch and Wallace, 1935, Amer. Mus. Nov., 794:7-8, figs. 33, 35 (male, female, Levy Lake, Florida, A.M.N.H., examined).

Remarks on types.—We measured the carapace of the male holotype as 1.87 mm long, 1.32 mm wide (vs. 1.80 mm long, 1.25 mm wide in original description) and that of female allotype as 1.87 mm long, 1.27 mm wide (vs. 1.75 mm long, 1.20 mm wide in original description). Both types have submarginal light band on the carapace (Figs. 32-33). We also found the anterior eye row of the allotype to be narrower than the posterior median row as described.

Diagnosis.—*Pirata seminola*, in Florida, with submarginal light band and banded legs resembled *P. insularis* in appearance, but is smaller and differs in genitalia. The epigynum resembles that of *P. insularis*, but the palpi are quite different. The distal process of the median apophyses of these two species are quite different in structure; the differences in the genitalia can best be determined by studying Figs. 38, 84.

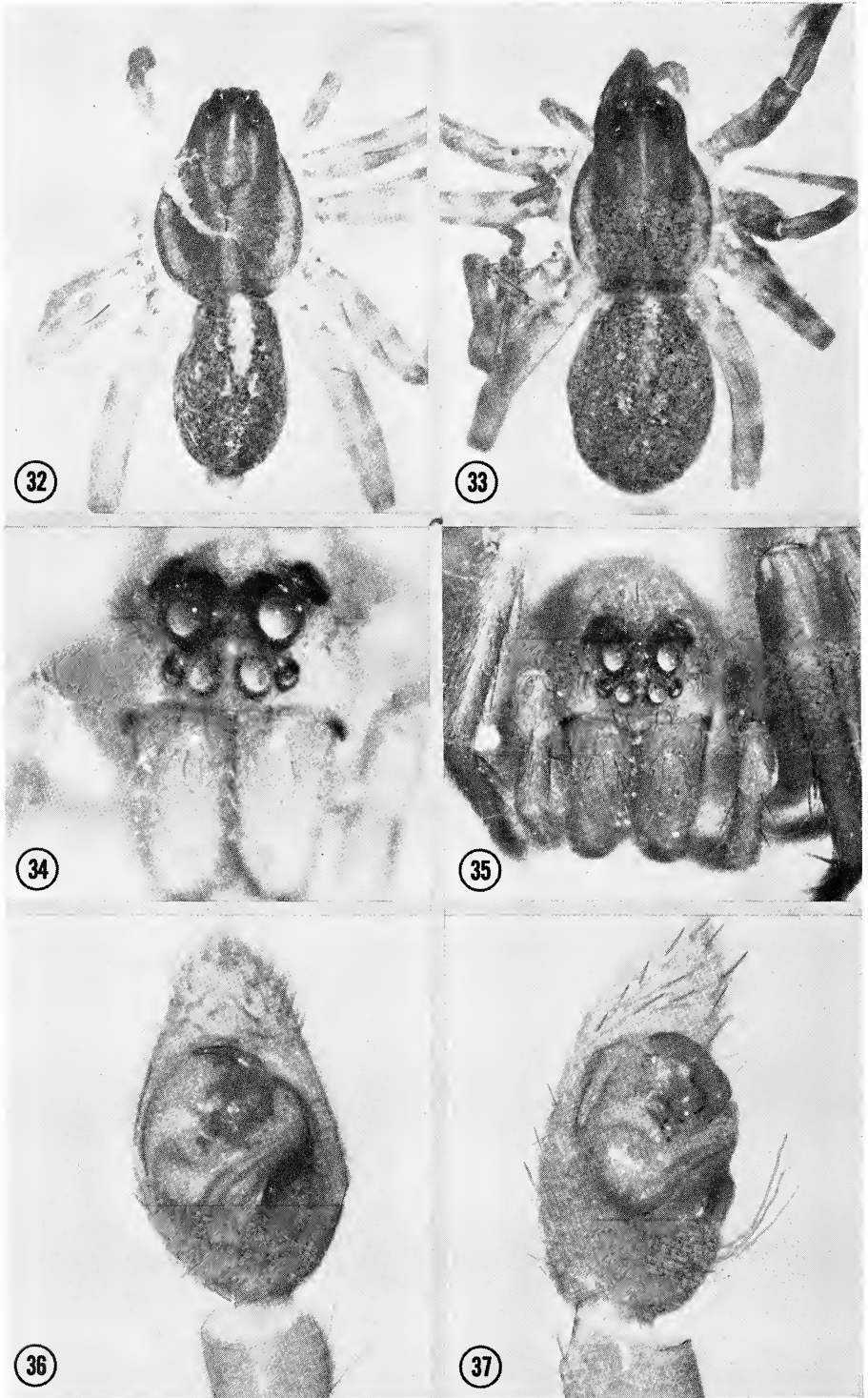
The median apophysis of *P. seminola* lacks the proximal process of *P. nanatus* and *P. welakae*, n. sp.

Variation.—*P. seminola* varies both in size and appearance. Males vary in carapace length from 1.5 mm to 2.2 mm, females from 1.5 mm to 2.3 mm. In Florida *P. seminola* has a distinct submarginal light band on the carapace and annulae on the legs. In Arkansas this species has a marginal light band on the carapace and no annulae, although sometimes there is a dark rim on the carapace. In a collection of twelve males from Hamburg, Louisiana, the pattern on the carapace varies from a wide marginal light area to a distinct submarginal stripe or band. The wide band forms are identical in appearance to Arkansas specimens. In Arkansas and Missouri there is much variation in size.

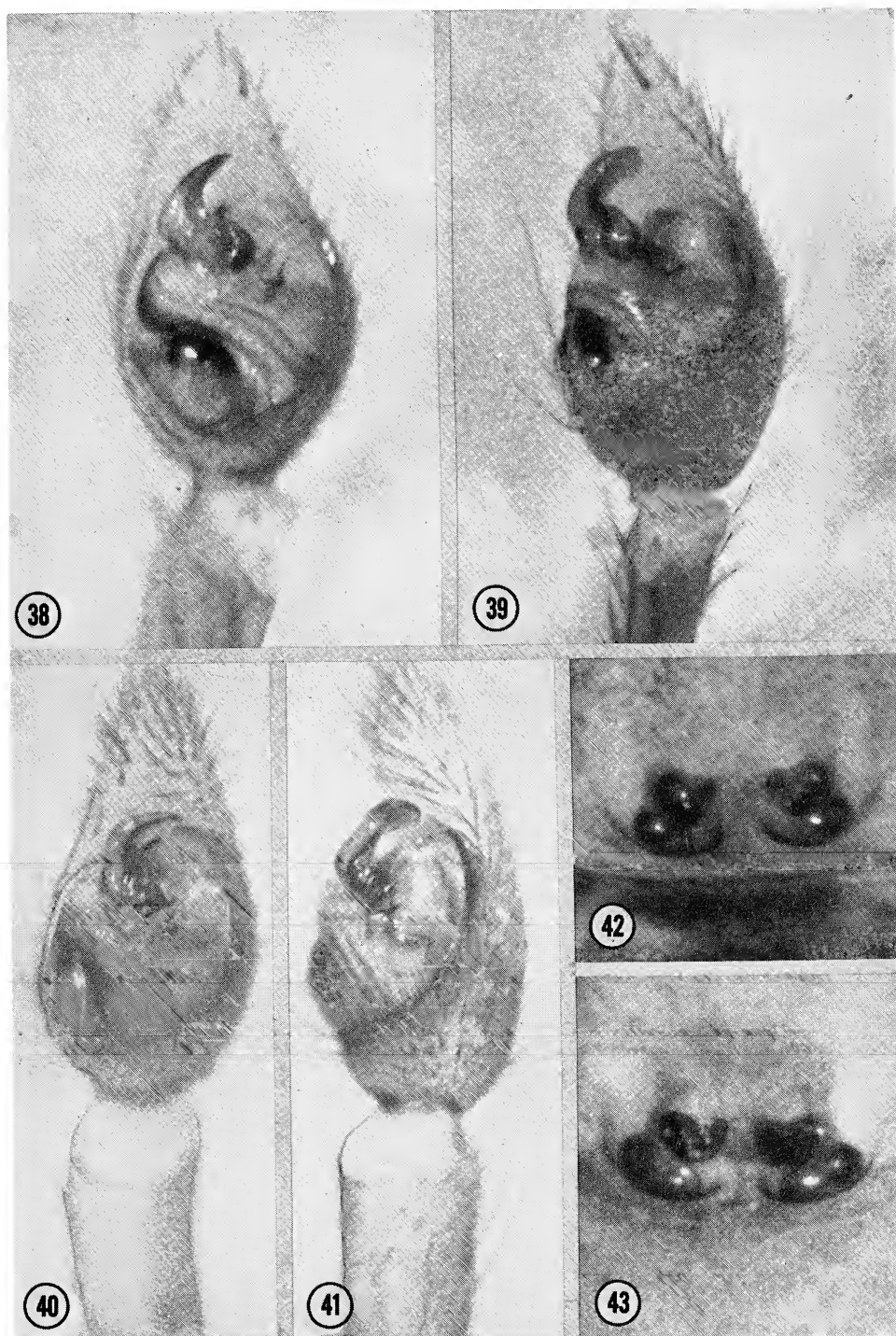
The angle which the distal process makes with the body of the median apophysis appears to vary in Arkansas males. In some it is almost 90 degrees and the tip does not extend much beyond the rim of the excavation of the cymbium. In others (Fig. 38) the median apophysis is rotated so that the angle appears smaller and the tip extends well beyond the rim as in *P. nanatus*.

Distribution.—The distribution of *P. seminola* is spotty and raises questions. Why, for example, the blanks from Georgia to New Jersey, Michigan and Louisiana? There is no pattern that we can detect. Perhaps more than one species is involved!

Specimens examined.—*Arkansas*: Bradley Co.: 8-VI-63, Crim 20, female (H.E.), 25-V-63, Crim 22, 2 females (H.E.); Conway Co.: 19-VI-63, Comp 8, male (H.E.), 22-VIII-61, W2-183W, female (H.E.), II-VII-63, Comp. 16, Traford, pitfall trap, male, female (H.E.), VIII-5-60, W-76, fall trap, female (H.E.), July, 60, no. 21, Gertsch, 2 males (H.E.), VIII.18.61, W2-164, 2 females (H.E.), VIII.7.61, M-44, male (H.E.), July 60, 21, female (H.E.), 12 Aug 61, Mori-13, male (H.E.), 14-21-VII.65, pitfall trap, Morrilton Lab, male (H.E.), 7 Aug 61, Morrilton, 2 males, 1 female (H.E.), 28 July 61, CF-39, Morrilton, Gertsch, 2 males (H.E.), 23 Aug 61, CF-34, Morrilton, female (H.E.), VI.7-61, L-141, Morrilton, female (H.E.), VIII.7.61, M-44, male (H.E.), VI.7-61, VI.9-1961, L-130, Plummerville, male (H.E.); *Washington Co.*: Cove Creek, 26-v-62, HL-306, Hite, 3 females (H.E.), III.6.62, CL-197; O + M Hite, female and egg sac (H.E.), V-26-62, CL-170, O + M Hite, male (H.E.), 7 July 62, C. G 148, Hite, female (H.E.), VII-15-1961, HL-72, male (H.E.), 2-VI-62, CL-184, HiteHite, female (H.E.), 7-VII-65, B. A. Dumas, male (H.E.); *Florida*: Alachua Co.: Mar 25, 1934, McClanahan, female (A.M.N.H.), Levy Lake, III.14.34, H.K.W. 264, males, females (holotype, allotype, paratypes A.M.N.H., paratypes H.K.W.), Station 6-C, II.3-37, H.K.W., males, females (H.K.W. and A.M.N.H.), Station 7B, II.7.37, H.K.W., males, females (H.K.W.), Station 7B, IV.28.37, H.K.W., 2 females (H.K.W.), Station 6-C, 3-III.37, H.K.W., male, female (M.C.Z.); *Hernando Co.*: 1.3 mi. W of U.S. 19 on Fla. 50, pond margin in scrub, III.23-47, H.K.W. 1248, male (H.K.W.); *Highlands Co.*: Archbold Biol. Sta., II.3.43, M. Cazier 80, female (A.M.N.H.); *Jackson Co.*: 3 Apr 1953, HKW 1655, male, female (H.K.W.); *Louisiana*: Hamburg: 29-IV-63, R. T. Allen, 12 males (H.E.), 29 Apr 63, L.A.-1, 5 males, 1 female (H.E.), 29 Apr 63, LA-2, 10 males, 5 females (H.E.), 13-V-63, L.A.-18, T. Allen, 6 males, 4 females (H.E.), 13 May 63, LA-40, 4 males, 1 female (H.E.), 18 May 63, LA-18, 3 males, 1 female (H.E.); *New Jersey*: Burlington Co.: New Gretna, May 13, 49, male (A.M.N.H.); *Michigan*: Kalamazoo



Figs. 32-37.—*P. seminola*: 32, holotype male, Florida, Alachua Co.; 33, allotype female, Florida, Alachua Co.; 34, male, eyes, Florida, Alachua Co., Sta 6C, II-3-37; 35, female, eyes, Florida, Alachua Co., Sta 6C, II-3-37, holotype, palp.



Figs. 38-43.—*P. seminola*: 38-39, palp, Arkansas, Conway Co., 14-21-VII-65; 40-41, palp, Michigan, Kalamazoo Co., Gull Lake, 1-7 July 65; 42, allotype, epigynum; 43, epigynum, Florida, Levy Co., H.K.W. 264.

Co.: Gull Lake Biol Sta.: 15-22 July 65, T. F. Hlavac, female (D.E.B.), 5-11 July 65, T. F. Hlavac; pitfall trap, *Typha* marsh, male (D.E.B.); *Missouri*: Newton Co.: Newtonia, 28 Aug 61, Peck, 1 female (H.E.); Dent Co.: Hobson Hts, May 2, 69, H.E.F., male, female, egg sac (H.E.); *Texas*: Henderson Co.: Swamp 9 mi. W of Athens, May 24, 1942, O. Saunders, female (H.E.); Travis Co.: Austin, July 7, 46, D. L. and H. Frizzell, male (H.E.).

Life history.—*P. seminola* is a spring form in Florida. We have males and females from February and March, and several females from April. The other months are blank. North of Florida we have males and females from April through August, one female with egg sac in March and two females in October from Arkansas. The only other egg sac is from Missouri in May.

Ecology.—In Florida *P. seminola* appears to be a flatwoods form and to occur around the margins of ponds and lakes, or swamps. In Arkansas and Missouri it has been collected in pitfall traps in open fields and near water in various types of situations. In Michigan it was taken in a pitfall in a *Typha* marsh; in Texas in a swamp.

Pirata welakae, n. sp.

Figs. 44-50

Holotype.—Male, Florida, Putnam Co., University of Florida Conservation Reserve, May 20, 1972, H. K. Wallace and Charles Harper, H.K.W. 1981 (A.M.N.H.).

Allotype.—Female with same data (A.M.N.H.).

Diagnosis.—At the U. of F. Conservation Reserve in Welaka, Florida, Wallace collected *P. welakae*, n. sp., and *P. apalacheus* Gertsch together by sifting thick layers of pine needles in situations where the ground was moist. The females of both species are about the same size and look alike, but the epigyna are quite different. The males are also similar in size and appearance, so much so that the palpi have to be examined to tell them apart. The median apophysis of *P. apalacheus* has a characteristic light spot at the tip of the distal process and the distal process is inclined laterally at less of an angle than in *P. welakae*. The distal process of *P. welakae* is somewhat shorter than that of *P. apalacheus*. The median apophysis of *P. welakae* lacks the basal process of *P. allapahae*; otherwise their palps look much alike. The palpal tibia of *P. allapahae* is relatively longer than that of *P. welakae* or *P. apalacheus*.

The genitalia of *P. welakae* most closely approach those of *P. sedentarius* in appearance, but the former is smaller than the latter and differs in pattern.

Description of holotype.—Carapace 1.55 mm long, 1.05 mm wide, glabrous, with numerous long hair-like bristles in head region and a wide marginal light area with dark pigmented rim. General body color, in alcohol, greenish yellow, black in eye region, the pigment on carapace rather diffuse, the tuning-fork pattern indistinct. Dorsum of abdomen with a distinct pattern (see Fig. 44). Coxae and femora greenish yellow above and below; tibiae and metarsi indistinctly banded. Labium, endites, coxae, sternum and venter yellow, immaculate. Anterior eye row much narrower than posterior median eye row (Fig. 46), procurved; anterior median eyes closer to each other than to anterior lateral eyes; anterior median eyes only slightly larger than anterior lateral eyes; clypeus is about equal to the diameter of anterior lateral eyes. Lower margin of furrow of chelicerae with three teeth, the middle tooth the largest, the lateral tooth the smallest. Legs 4123. Spines on tibia I long and overlapping. The palpus is very similar to that of *P. sedentarius* (Figs. 48-49).

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palp	0.48	0.22	0.25		0.52	1.47
Leg I	1.12	0.50	0.93	0.93	0.52	4.00
Leg II	0.95	0.50	0.78	0.83	0.50	3.56
Leg III	0.95	0.40	0.70	0.93	0.47	3.45
Leg IV	1.30	0.50	1.13	1.45	0.70	5.08

Description of allotype.—Carapace 1.70 mm long, 1.13 mm wide. Pattern similar to male (Fig. 45), but legs more distinctly banded. Carapace glabrous like in some species of *Arctosa*. Anterior eye row narrower than posterior median eye row (Fig. 47), procurved; anterior median eyes closer to each other than to laterals, slightly larger than laterals. Clypeus about equal to the diameter of anterior lateral eyes. Legs 4123. Openings to sperm canals on ventral surface in center of lobes. Epigynum (Fig. 50).

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.50	0.27	0.37		0.50	1.64
Leg I	1.25	0.55	1.00	0.98	0.50	4.28
Leg II	1.18	0.52	0.92	0.92	0.50	4.04
Leg III	1.08	0.47	0.80	0.95	0.48	3.78
Leg IV	1.50	0.55	1.33	1.70	0.70	5.78

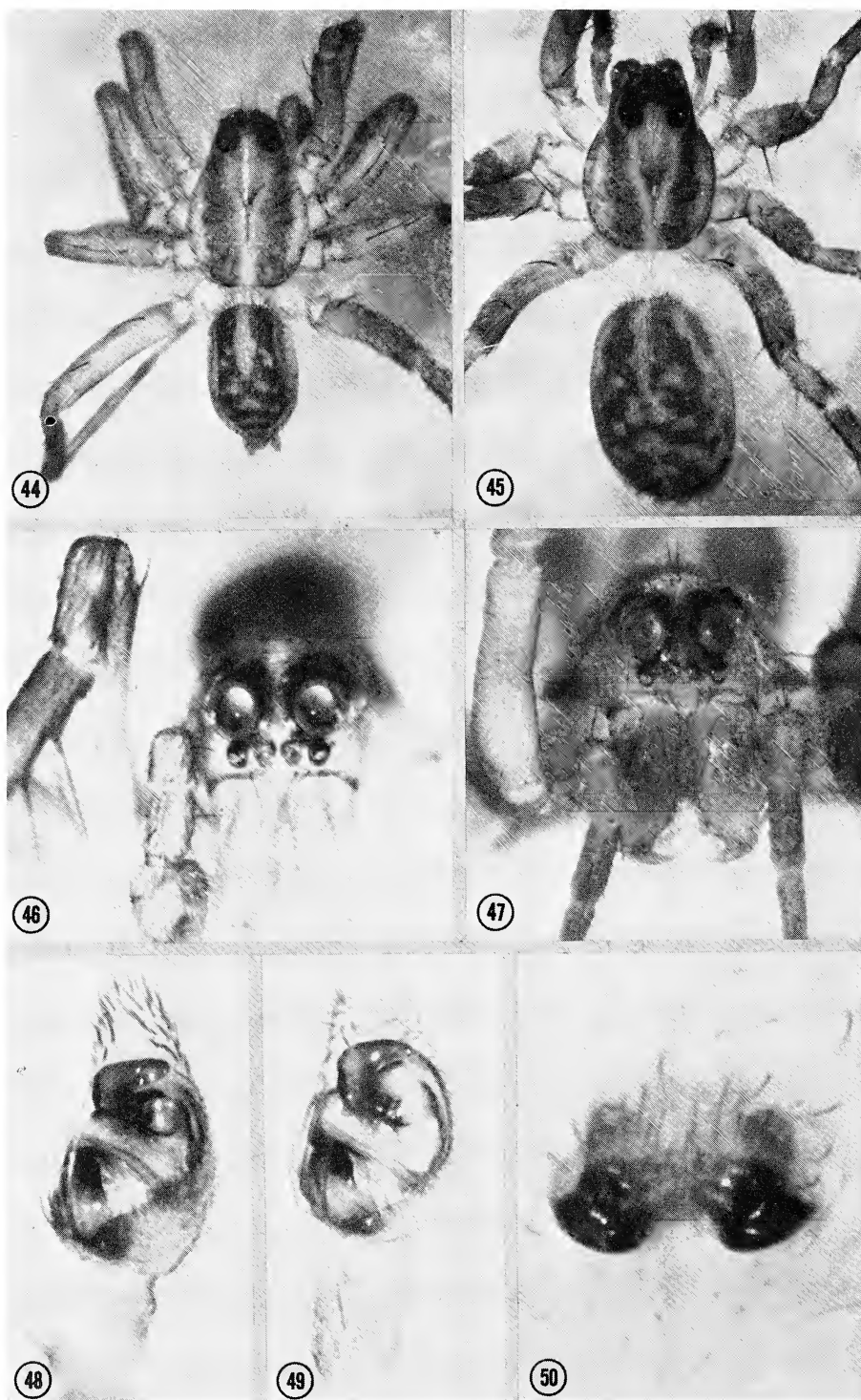
Descriptive notes on females.—From Putnam Co., Florida, VI.3.47, HKW 1267. Carapace of female no. 1, 1.6 mm long, 1.1 mm wide. Pattern on carapace indistinct, but appears to have a wide marginal light area. The anterior eye row is shorter than the posterior median eye row, procurved; anterior median eyes are closer to each other than the laterals; anterior median eyes one and one-fourth times as large as anterior lateral eyes. Clypeus equals diameter of anterior median eyes. Legs unbanded. Tibia I with long, overlapping spines. Legs 4132.

Distribution.—Columbia and Putnam Counties, Florida.
Specimens examined.—*Florida*: Columbia County: 12 mi. north Lake City, Dec. 22, 1962, W. Ivie, female (A.M.N.H.); Putnam County: U of F Conservation Reserve, VI.3.47, P-7, HKW 1267, 2 males, 4 females (D.P.I.), VI.6.47, 0-67, H.K.W. 1273A, 5 males, 11 females, egg sacs (D.P.I.); VI.7.47, P-70, H.K.W. 1275A, female (D.P.I.), V.20.72, G-56, H.K.W.1981, 5 males, 4 females (holotype and allotype, A.M.N.H.; paratypes, D.P.I.), V.26.72, G-56, H.K.W. 1984, 24 males, 27 females (D.P.I.).

Life history.—We have males and females from May and June from Putnam County and we think we collected females with egg sacs in May. The record from Columbia County in December may be due to misidentification; this locality record needs to be confirmed by additional collections.

Ecology.—*P. welakae* appears not to be confined to the margins of standing water. On the Reserve at Welaka where fire has been kept out for many years the leaf litter becomes eight to ten inches deep with the top layers forming a dry roof above the damp, dark rotting layers beneath. In pine flatwoods the pine needles form a thick carpet supported by clumps of the grass *Aristida stricta* and providing a moist dark habitat where Wallace has collected *P. welakae*, *P. apalacheus*, *Trabea aurantiaca*, *P. (Sosilaus) spiniger*, *P. insularis* and *Arctosa furtiva*.

The sawmill pond on the Reserve has a border of long-leaf pines above the high water zone. Sifting the pine needles from under these trees yields *P. welakae*, *P. apalacheus*, *P. insularis* and *Trabea aurantiaca*. Headlight collecting between the pines and the water on



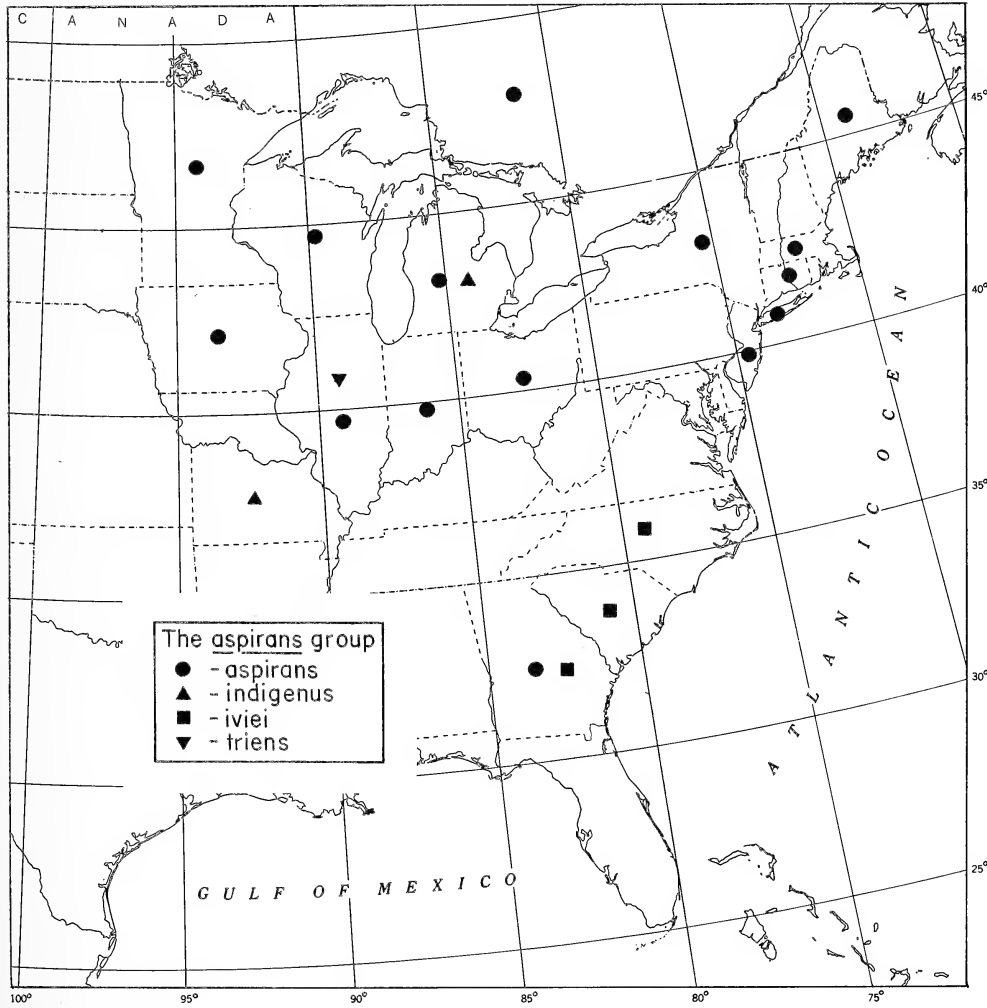
Figs. 44-50.—*P. welakae*, n. sp.: 44, holotype male, Florida, Putnam Co.; 45, allotype female, Florida, Putnam Co.; 46, holotype, eyes; 47, allotype, eyes; 48-49, holotype, palp; 50, allotype, epigynum.

black mud flats or by examining sphagnum moss yields *P. allapahae*, *P. insularis*, *P. suwaneus*, *P. mayaca* and *Arctosa furtiva*.

P. welakae and *P. apalacheus* have also been collected in the leaf litter of mesic hammock on the Reserve.

THE *ASPIRANS* GROUP

P. aspirans, *P. triens*, n. sp., *P. indigenus*, n. sp. and *P. iviei*, n. sp., are a related group having similar patterns and genitalia that appear to have diverged from the same source (Figs. 51-76). *P. mayaca*, *P. pagicola*, and *P. davis*, n. sp., have epigyna that are somewhat similar to the *aspirans* group, but their palps are different unless the median apophysis of *P. pagicola*, *P. mayaca*, and *P. davis*, n. sp., represent an extreme of the type of modification from that of *P. aspirans* seen in *P. triens*, n. sp., in which the apex of the median apophysis is drawn out laterally to form a finger-like process and medially is reduced to nothing.



P. aspirans Chamberlin

Figs. 51-60

Pirata aspirans Chamberlin, 1904, Canadian Entomol., 36(10):286-287 (male, female, Virginia, North Carolina; the types are not in M.C.Z. and were not examined; are presumably lost; see remarks); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:303-305, pl. XXII, fig. 4, 5 (male, female figures, but mislabeled; see remarks).
Pirata arenicola Emerton, 1909, Trans. Connecticut Acad. Arts and Sci., 14:208-209, pl. VI, figs. 9-9C (male, female, Ipswich, Mass., M.C.Z., examined). Female = *piraticus*; male = *aspirans*. NEW SYNONYMY.

Description of male.—From the E. S. George Reserve, Livingston Co., Michigan, VIII-3-51, H.K.W. 1448. Carapace 2.07 mm long, 1.55 mm wide, with a wide marginal light area and the usual tuning-fork pattern. Dorsum heavily pigmented, with narrow light colored area over the heart and four pairs of patches of white scales. Coxae and endites light, without pigment, sternum and labium lightly pigmented; venter with irregular patches of pigment.

Anterior eye row narrower than median row, slightly procurved; the anterior median eyes twice as large as laterals, closer to laterals than to each other. Clypeus height equal to diameter of anterior lateral eye. Lower margin of furrow of chelicerae armed with three unequal teeth, the middle tooth the largest, the lateral the smallest, the middle tooth closer to the lateral than to the median.

Legs 4123, banded. Tibia I with seven ventral and lateral spines. Tibia II with eight ventral and lateral spines. For palpus see Fig. 58.

Description of female.—Same data as male. Carapace 2.20 mm long, 1.58 mm wide, with a wide marginal light area and tuning fork pattern; color and pattern as in the male (Figs. 56-57). Eye arrangement and dentition of chelicerae as in the male. Epigynum (Fig. 60).

Legs 4123, faintly banded. Tibia I with six ventral and lateral spines. Tibia II with five ventral and lateral spines.

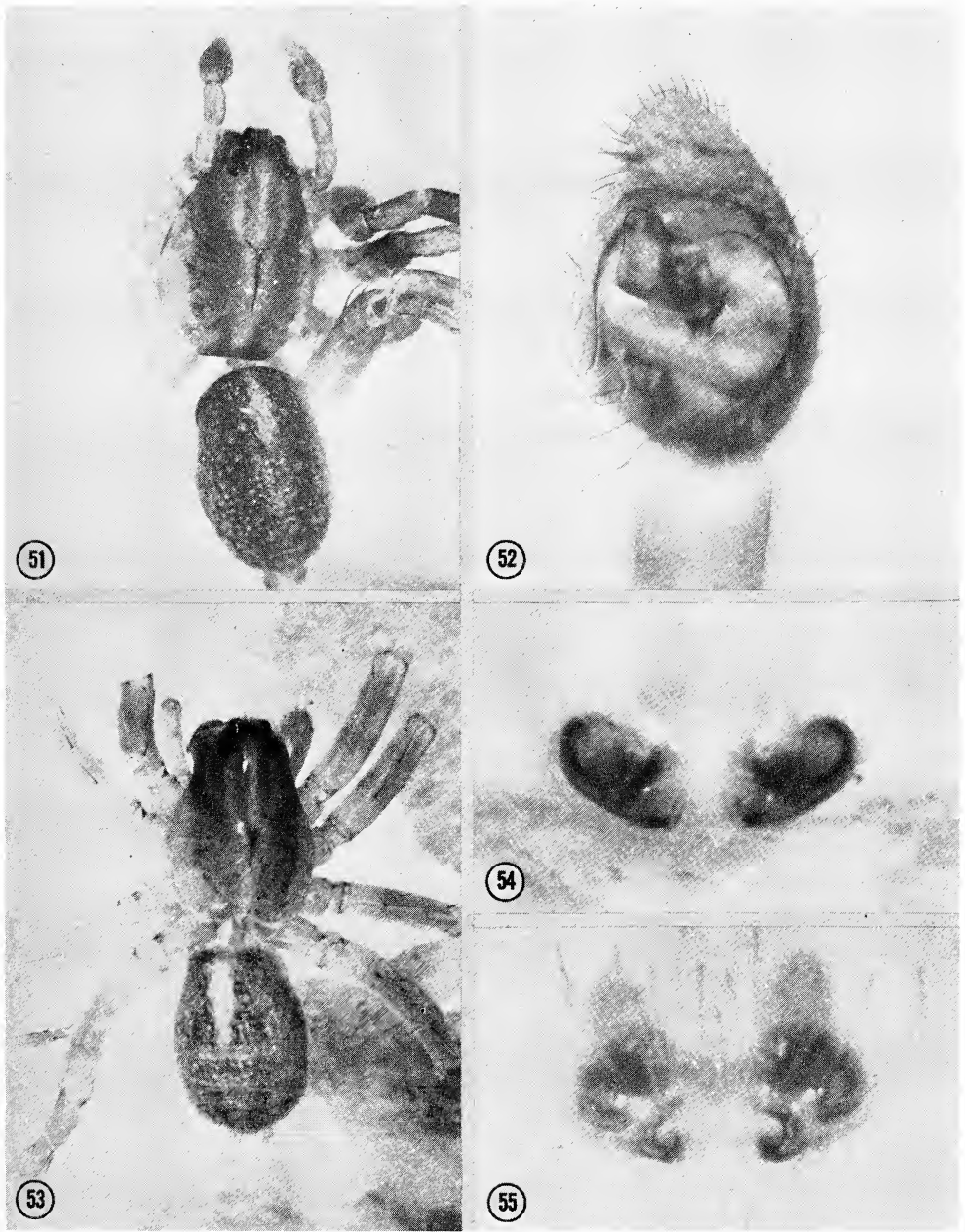
Variations and observations.—This species resembles *P. piraticus* in appearance with its wide marginal light area, although sometimes it appears to have a submarginal light area. Michigan specimens have distinctly banded legs. Five females from Crosswick, New Jersey, have an epigynum that looks different; we need males. In fact any record based on a female in this group should be considered tentative until backed up by the capture of a male in the same locality.

Epigynum of *P. aspirans* is very similar in appearance to that of *P. mayaca* and *P. pagicola*, but the median apophysis of the palps are quite different; also *P. mayaca* in Florida has a submarginal band on the carapace while *P. aspirans* has a wide marginal light area. The pattern of *P. pagicola* is more like that of *P. aspirans*.

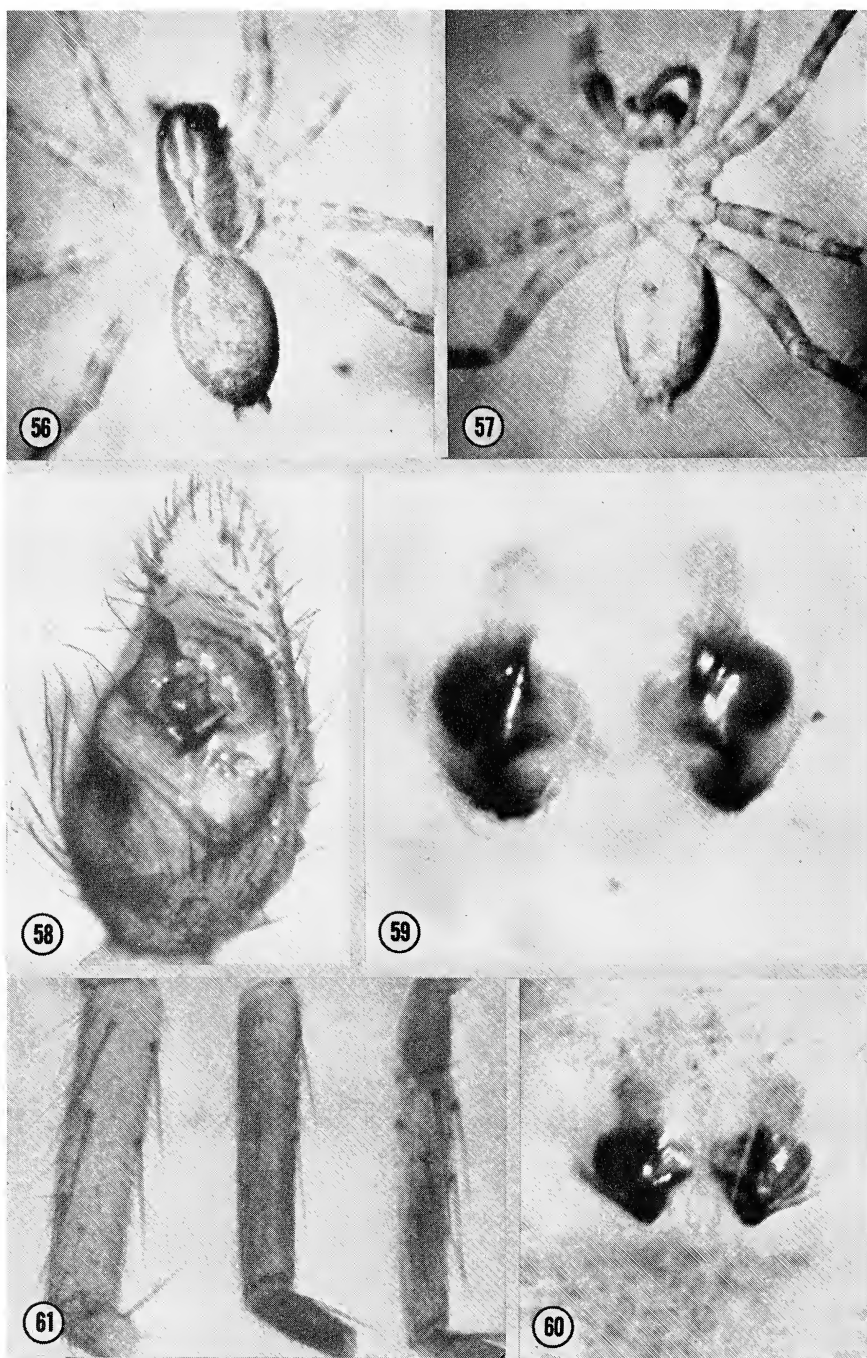
Distribution.—Northeastern United States and Canada, east of the Dakotas. One male known from Georgia; others have been reported from North Carolina, Virginia and Washington, D.C.

Specimens examined.—Canada: *Ontario*; *Quebec*. United States: *Connecticut*: Fairfield, Litchfield, New Haven Counties; *Georgia*: Floyd County; *Illinois*: Adams, Cook, Lake, Lee Counties, Volo; *Indiana*: Porter County; *Iowa*: Cerro Gordo and Dickinson Counties; *Maine*: Knox County, Isle au Haut; *Massachusetts*: Essex, Middlesex Counties; *Michigan*: Arenac, Calhoun, Cheboygan, Ingham, Kalamazoo, Livingston, Macomb,

Mecosta, Midland, Oakland, Washtenau Counties, Selridge Field; *Minnesota*: Freeborn County, Albert Lea; *New Jersey*: Burlington County, Crosswicks; *New York*: Rensselaer, Schenectady, Suffolk, Tompkins Counties, Enfield Glen, Orient, Long Island, Rensselaerville; *Ohio*: Erie, Wayne Counties; *Wisconsin*: Iron, Marienette, Rock Counties, Hurley.



Figs. 51-54.—*P. arenicola*: 51, male type (= *P. aspirans*), Massachusetts, Ipswich, June 6, 1903; 52, male type (= *P. aspirans*), palp; 53, female type (= *P. piraticus*), Massachusetts, Ipswich, June 6, 1903; 54, female type (= *P. piraticus*), epigynum.
Fig. 55.—*P. aspirans*: Epigynum, Connecticut, New Haven.



Figs. 56-60.—*P. aspirans*: 56, female, dorsal surface, Michigan, Livingston Co., E.S.G.R., H.K.W. 1448; 57, female, ventral surface, Michigan, Livingston Co., E.S.G.R., HKW 1448; 58, palp, Michigan, Livingston Co., E.S.G.R., H.K.W. 1410; 59, epigynum, New Jersey, Crosswicks; 60, epigynum, Michigan, Livingston Co., HKW. 1448.

Fig. 61.—Tibia I. Left: *P. seminola*, Florida, Alachua Co., Sta. 6C; Middle: *P. allapahae*, Florida, Pasco Co., H.K.W. 1242; Right: *P. nanatus*, Florida, Turner Co., II-5-37.

Life history.—*Pirata aspirans* appears to be a summer form. Males have been taken from May into August but most from June and July. The earliest record of a female is from April, none in May and three from September. Most of the records are from June, July and August. Females with egg sacs have been taken in June, July and August. Kaston (1948) writes that, in Connecticut, "individuals mature in late May and early June."

Ecology.—In Michigan this species occurs along with *P. piraticus* and *P. insularis* in wet areas in swamps and bogs, around woods ponds with *P. piraticus*, and in marshes. *P. minutus* and *P. aspirans* are found in the same vial in collections by R. V. Chamberlin from Wisconsin and Michigan.

Remarks.—In 1904 Chamberlin described *Pirata aspirans* from three specimens, including a female and a male, from Virginia and North Carolina. He did not describe the male, nor did he illustrate the genitalia of either sex, but he did indicate the presence of a marginal light area on the carapace and compare the epigynum to that of *P. humicolus* (*minutus*) in such a way as to suggest he had before him what subsequent authors have been naming *P. arenicola* Emerton. In 1908 Chamberlin redescribed and figured *P. aspirans*, but unfortunately reversed the numbers on the figures of the epigyna of *P. aspirans* and *P. insularis* (as pointed out by Kaston in 1948). The figure of the male palp is quite characteristic of *P. arenicola* although the figure of the epigynum is dubious. However, he only gives Washington, D.C., for locality. Unfortunately the types are missing.

What did Chamberlin have before him when he described *P. aspirans* in 1904? There are no specimens that fit his 1908 description from North Carolina or Virginia in any collections that we have examined. We have found one male from Chapel Hill, North Carolina which is closely related, but which is a member of the new species we are describing from Georgia as *P. iviei*.

The absence of specimens in collections from North Carolina, Virginia and Washington, D.C., is disturbing, but in view of the small amount of collecting which apparently has been done in those areas we believe we can not rule out the possibility that *P. aspirans* does occur there. In any case it is quite clear what Chamberlin had before him in 1908 when he redescribed *P. aspirans*. Kaston (1948) recognized *P. aspirans* when he synonymized it with *P. arenicola* Emerton, and Bonnet (1958) lists both *P. aspirans* and *P. arenicola* as good species. It is our opinion that subsequent authors, confused by the mix-up in figure numbers in Chamberlin's 1908 paper, assumed that *P. aspirans* and *P. arenicola* were different species. Since we now know that this is not the case *P. aspirans* must replace *P. arenicola*.

Although it has no bearing on the priority of these two names it is interesting that the female type of *P. arenicola*, which Emerton cites first in his description, is *P. piraticus* (Cl).

Description of Emerton's types.—Male: carapace 2.1 mm long, 1.5 mm wide, with a wide marginal light band and typical tuning-fork pattern (Fig. 51). Anterior eye row slightly narrower than the posterior median row, almost straight. The anterior median eyes are twice as large as the laterals and are closer to the laterals than to each other. Emerton figured the palpus accurately (9b) (Fig. 52).

Female: This is *P. piraticus* Clerck. Emerton's figures of the epigynum (9c) and carapace (9a) match these structures (Figs. 53-54). The carapace is 3.0 mm long, 2.1 mm wide. The pattern on the carapace is typical of *P. piraticus* with wide marginal light band, resembling the male type above very closely, accounting no doubt for Emerton's confusion.

Pirata indigenus, n. sp.

Figs. 62-65, 72

Holotype.—Female from Meramec River, Crawford Co., Missouri, 14-18 July, 1966, HEF & DLF (Exline), A.M.N.H.

Diagnosis.—This species appears to be a member of the *aspirans* complex. The epigynum (Figs. 63, 65) is wider and shorter than *P. aspirans*, *P. davisii*, n. sp., or *P. triens*, n. sp. It differs from *P. davisii* in the spination of tibia I. They all resemble one another in appearance, and are characterized by the wide marginal light band on the carapace.

Description of holotype.—Carapace 1.95 mm long, 1.67 mm wide with a wide marginal light band a little pigment visible faintly through the edge; the tuning-fork pattern on the head is not very distinct (Fig. 62). Basic color yellow. Pattern on dorsum nondescript with dim traces of what must have been white spots in life. Lower margin of furrow of chelicerae with three teeth, middle the largest, the one next to the fang very small. Anterior eye row narrower than posterior median eye row; distinctly procurved; anterior median eyes almost twice as large as anterior lateral eyes; anterior median eyes closer to anterior lateral eyes than to each other.

Coxae, sternum, endites yellow, immaculate; labium a little darker; venter pigmented with patchy spots in middle and laterally. Legs 4132, yellow, unbanded except for faint traces of two annulae on femora III. Tibia I with five ventral overlapping spines, two retrolateral, three prolateral.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palp	0.77	0.37	0.55		0.65	2.34
Leg I	1.77	0.82	1.47	1.42	0.62	6.10
Leg II	1.50	0.65	1.20	1.25	0.57	5.17
Leg III	1.62	0.70	1.17	1.50	0.65	5.64
Leg IV	2.20	0.80	2.02	2.50	0.87	8.39

Distribution.—Michigan and Missouri.

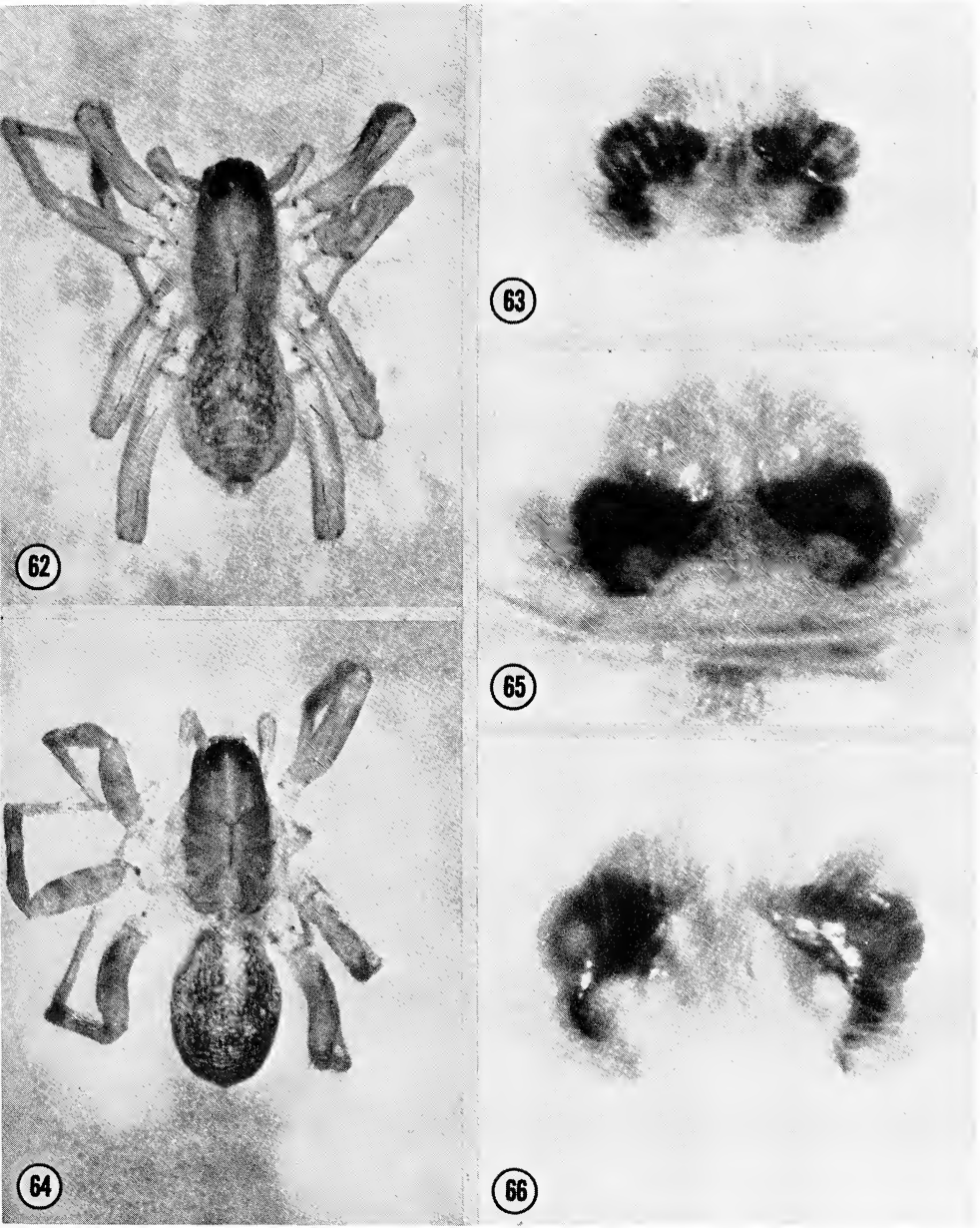
Specimens examined.—*Missouri*: Crawford Co., Meramec River 14-18 July, 1966, HEF & DLF, 5 females (Exline); *Michigan*: Midland Co., A. M. Chickering, one female (M.C.Z.).

Life history.—We have examined a female with egg sac in July from Missouri and in August from Michigan. The male is unknown.

Variations.—In the vial from Meramec River there were seven females, one of which is in poor condition, and an egg sac. The six good specimens, including the holotype, are quite uniform in appearance, but vary somewhat in the size and shape of the carapace. The epigyna of all seven specimens are quite similar in structure. Measurements of the six carapaces: Holotype, 1.96 mm long, 1.67 mm wide; Specimen 2, 1.95 mm long, 1.30 mm wide; Specimen 3, 2.05 mm long, 1.40 mm wide; Specimen 4, 2.07 mm long, 1.50 mm wide; Specimen 5, 2.22 mm long, 1.55 mm wide; Specimen 6, 2.25 mm long, 1.57 mm wide.

Description of female from Michigan.—Carapace 2.4 mm long, 1.72 mm wide. In alcohol the basic color pattern is amber. Carapace with a wide marginal light band interrupted by several faint pigmented spots along the margins (Fig. 64). Central part of carapace rather heavily pigmented, the tuning fork pattern almost completely obliterated; eye region darker.

Sternum, coxae, endites light amber, immaculate, labium darker. Dorsum of abdomen with hastate mark, heavily pigmented; venter pigmented somewhat like *P. sedentarius*. Lower margin of furrow of chelicerae with three teeth; middle tooth the largest, tooth nearest base of fang very much reduced.



Figs. 62-65.—*P. indigenus*, n. sp.: 62, holotype female, Missouri, Crawford Co.; 63, holotype, epigynum; 64, female, Michigan, Midland Co.; 65, epigynum, Michigan, Midland Co.
Fig. 66.—*P. triens*, n. sp. Epigynum, Illinois, Adams Co., Quincy, VI-10-58.

Anterior eye row narrower than posterior median eye row, slightly procurved; anterior median eyes about half again as large as anterior eye row; anterior median eyes closer to anterior lateral eyes than to each other. Clypeus equal to the diameter of an anterior median eye, receding.

Legs 4132, banded. Tibia I with long, overlapping ventrolateral spines; three prolateral, two retrolateral.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palp	0.80	0.43	0.53		0.67	2.43
Leg I	1.75	0.80	1.48	1.37	0.58	5.98
Leg II	1.67	0.75	1.25	1.30	0.57	5.54
Leg III	1.62	0.70	1.20	1.50	0.62	5.64
Leg IV	2.20	0.80	2.00	2.55	0.88	8.43

Remarks.—The female paratype from Michigan is larger than the Missouri specimens, but otherwise resembles them in appearance. The epigynum of the paratype from Michigan is a little different in shape from the Missouri specimens and femur II is longer than femur III and just the reverse in the holotype; when males are known we may find these two are separate species.

***Pirata iviei*, n. sp.**

Figs. 67-71

Holotype.—Male, Lyons, Georgia, June 11, 1935, W. Ivie, W 82° 17': N 32° 9' (A.M.N.H.).

Allotype.—Female, with same data (A.M.N.H.).

Etymology.—This species is named for Mr. Wilton Ivie, lifelong student and collector of spiders.

Diagnosis.—*P. iviei* differs from *P. aspirans* in having a distinct submarginal band on carapace, in having a larger epigynum, and in the shape of the median apophysis of the palp, which has a round distal flange instead of a more or less rectangular flange as in *P. aspirans*.

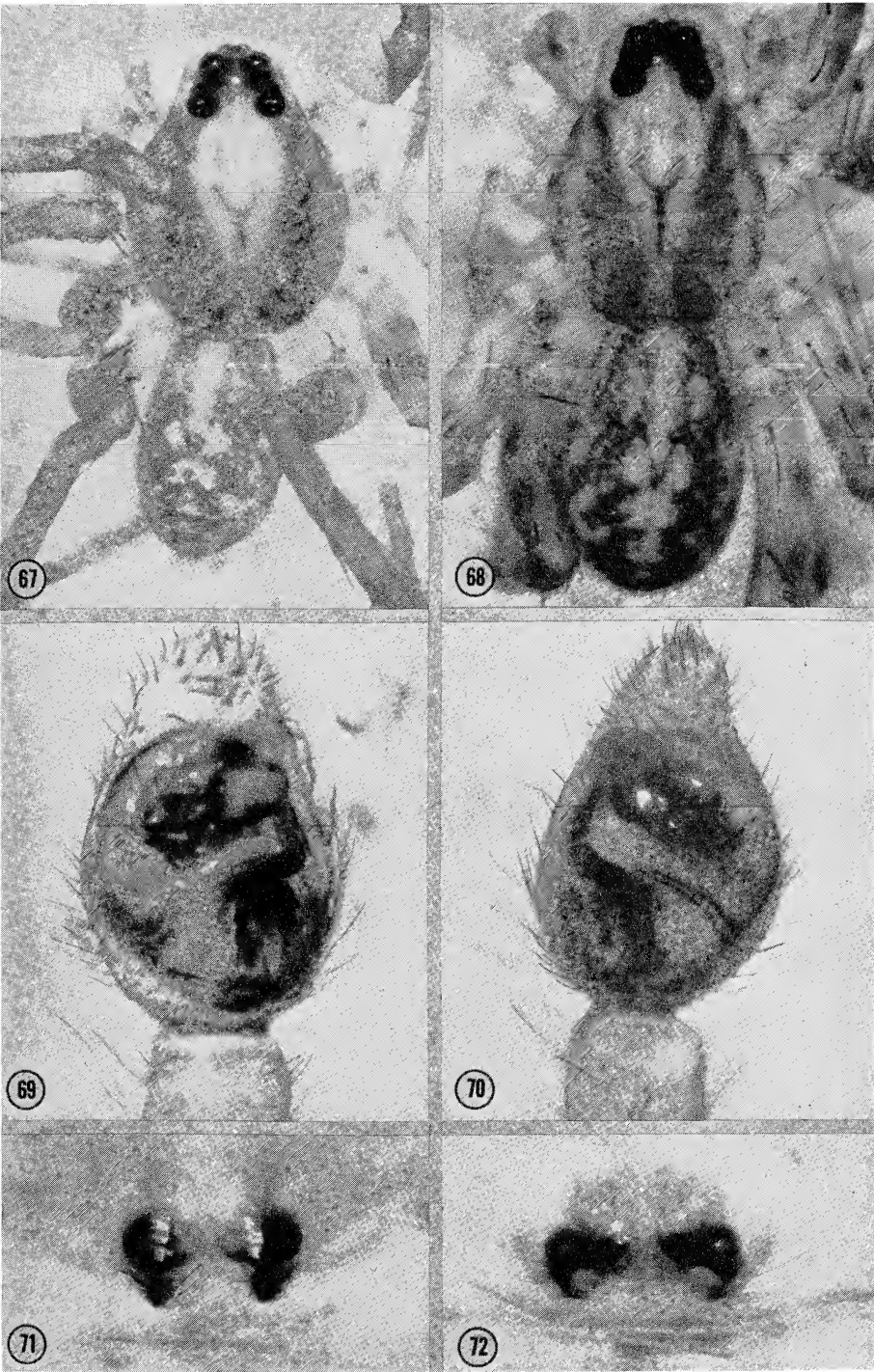
Description of male holotype.—Carapace 1.8 mm long, 1.32 mm wide, with the usual tuning-fork pattern and a submarginal light band but the marginal pigment is very scanty and discontinuous. (Fig. 67). Ventral surface of coxae, sternum, etc. light, unpigmented except for a patch of pigment in the center of the venter. Lower margin of the furrow of the chelicerae with three unequal teeth, the middle tooth the largest, the lateral tooth the smallest; middle tooth closer to the lateral than to the median.

Anterior eye row narrower than the median row, procurved. The anterior median eyes are closer to the laterals than to each other and are twice as large. Clypeus height slightly less than the diameter of an anterior median eye.

The median apophysis of the palp is basically similar to that of *P. aspirans* but the distal flange (Fig. 69) is much larger and is round where that of *P. aspirans* is rectangular.

Legs 4123, lightly banded.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.60	0.25	0.33		0.56	1.74
Leg I	1.23	0.58	1.00	1.13	0.56	4.50
Leg II	1.15	0.57	0.93	1.03	0.53	4.21
Leg III	1.12	0.53	0.80	1.03	0.52	4.00
Leg IV	1.56	0.63	1.32	1.63	0.70	5.84



Figs. 67-71.—*P. iviei*, n. sp.: 67, holotype male, Georgia, Lyons; 68, allotype female, Georgia, Lyons; 69, holotype, palp; 70, palp, North Carolina, Durham Co., New Hope Creek; 71, allotype, epigynum.

Fig. 72.—*P. indigenus*, n. sp.: Epigynum, Michigan, Midland Co.

Description of female allotype.—Carapace 2.0 mm long, 1.45 mm wide with submarginal light band and tuning-fork pattern (Fig. 68). Anterior eye row narrower than median row, procurved; anterior median eyes closer to laterals than to each other and twice as large. Lower margin of the furrow of the chelicerae with three unequal teeth, the middle tooth the largest and slightly closer to the lateral than the median; median and lateral teeth about the same size. Clypeus height about equal to the diameter of an anterior median eye.

The epigynum of *P. iviei* resembles that of *P. aspirans*.

Legs 4123, distinctly banded.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.64	0.32	0.43		0.56	1.95
Leg I	1.45	0.70	1.22	1.20	0.58	5.15
Leg II	1.35	0.67	1.05	1.18	0.55	4.80
Leg III	1.30	0.55	0.98	1.25	0.55	4.63
Leg IV	1.75	0.62	1.56	1.95	0.77	6.65

There were four additional females in the vial with the holotype and allotype. All females were uniform in size but two of these paratypes were so lightly pigmented along the edges of the carapace as to appear to have a broad marginal light band.

Distribution.—Southeastern United States.

Specimens examined.—*Georgia*: Lyons, June 11, 1935, W 82° 17' N 32° 9', W. Ivie, 1 male, 5 females (male holotype, female allotype, A.M.N.H.); *North Carolina*: Durham County, Chapel Hill Blvd. (US 15-501), at New Hope Creek (S of road) pitfall, J. W. Berry, male (A.M.N.H.); *South Carolina*: Aiken County, 5 mi N Aiken, VI-30-39, H.K.W. 1089A, 2 females (H.K.W.).

Life History.—All the specimens we have examined are from June and July with one egg sac from June.

Ecology.—The male from North Carolina was collected in a pitfall in "hardwood bottom land." The two females from South Carolina were collected in a wet hammock. We have no habitat information for the Georgia specimens.

Remarks.—The epigynum of *P. iviei* is very close to that of *P. aspirans* and *P. davisi* but the median apophysis of the palpi differ considerably.

Whether this species has a submarginal or marginal light band on the carapace depends upon how heavily the animal is pigmented.

Pirata triens, n. sp.

Figs. 73-76

Holotype.—Male from Quincy, Adams Co., Illinois, 10 June 1958, moist woods, J.L.K. (A.M.N.H.).

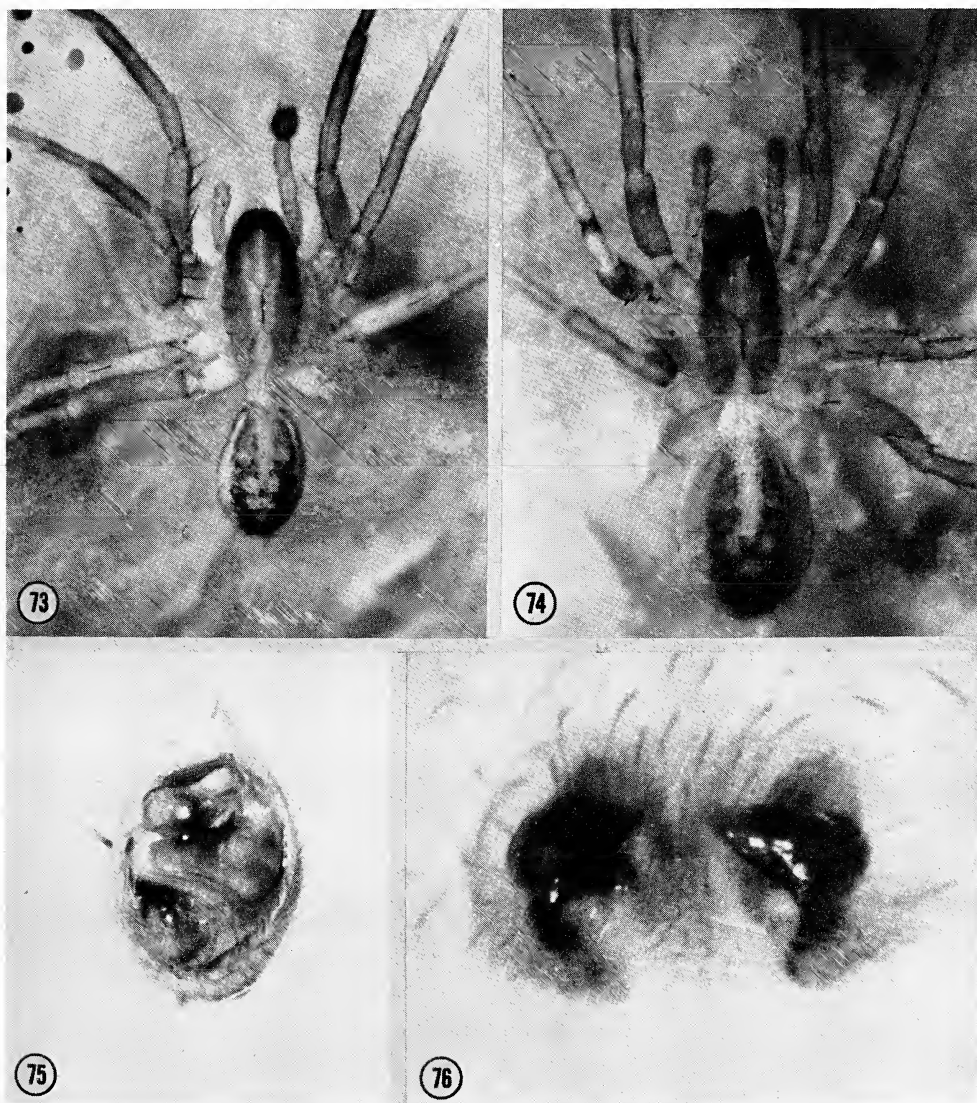
Allotype.—Female with same data (A.M.N.H.).

Etymology.—This species is named *triens* (a third part) because it was the third new species we found in the *aspirans* group.

Diagnosis.—*P. triens* is a member of the *aspirans* group (*P. iviei*, n. sp., and *P. indigenus*, n. sp.). It has the wide marginal light band on the carapace but lacks the annulations on the legs of *P. aspirans*. The types are very light in color (Figs. 73-74); more heavily pigmented specimens might have banded legs. The palpus and epigynum of *P.*

triens are quite distinct (Figs. 75-76); the lateral process of the median apophysis is a long spatulate appendage, much longer than in *P. aspirans*, and the distal process is reduced to nothing. The epigynum is narrower and longer than in *P. aspirans* or *P. indigenus*.

Description of holotype.—Total length 4.0 mm. Carapace 2.00 mm long, 1.48 mm wide. Basic color light yellow with unbanded legs. Carapace with distinct tuning-fork pattern and wide marginal light band. Dorsum with hastate mark followed by a pair of light circular areas containing a central dark spot, these followed by a rectangular light area with a dark central spot, this followed by indistinct chevrons. Lateral edges of dorsum with a longitudinal light band that extends forward almost to the front margin of the abdomen.



Figs. 73-76.—*P. triens*, n. sp.: 73, holotype male, Illinois, Adams Co., Quincy; 74, allotype female, Illinois, Adams Co., Quincy; 75, holotype, palp; 76, allotype, epigynum.

Coxae, labium, endites, and sternum light yellow, immaculate; venter with just a few faint pigment spots laterally. Lower margin of furrow of chelicerae with three teeth, the middle one the largest, the one nearest the fang the smallest.

Anterior eye row narrower than the posterior median row, slightly procurved. The anterior median eyes are half again as large as the laterals, and are closer to the laterals than to each other. The clypeus height is slightly less than the diameter of an anterior median eye. For palpus see Fig. 75.

Legs 4123, without annulae.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.80	0.40	0.48		0.70	2.38
Leg I	1.55	0.70	1.20	1.23	0.63	5.31
Leg II	1.45	0.65	1.07	1.20	0.60	4.97
Leg III	1.38	0.56	0.97	1.23	0.60	4.74
Leg IV	1.90	0.72	1.67	2.05	0.79	7.13

Description of female allotype.—Total length 5.0 mm, carapace 2.12 mm long, 1.55 mm wide. Color pattern essentially as in the male. Dentition of chelicerae, height of clypeus, and eye arrangement as in the male. The epigynum is of the *P. aspirans* type (Fig. 76).

Legs 4123, without annulae.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.77	0.39	0.52		0.65	2.33
Leg I	1.73	0.75	1.45	1.35	0.62	5.90
Leg II	1.65	0.75	1.25	1.27	0.58	5.50
Leg III	1.52	0.65	1.17	1.45	0.65	5.44
Leg IV	2.20	0.82	2.03	2.58	0.62	8.25

Distribution.—Known only from the type specimens, which are from Illinois.

Ecology.—The types were collected in a "moist woods."

Remarks.—As indicated in the diagnosis *P. triens* is a member of the *aspirans* group. All have rather similar epigyna, but the median apophyses of the palpi differ conspicuously. The distribution of the members of this group suggests that speciation was brought about by isolation during periods of glaciation.

THE *INSULARIS* GROUP

Pirata insularis Emerton

Figs. 77-80, 83-86

Pirata insularis Emerton, 1885, Trans. Connecticut Acad. Sci., 6:492-493, pl. 48, figs. 8, 8a (3 females, Long Lake, New York; M.C.Z., examined; one selected here as LECTOTYPE; Note: Fig. 8a is upside down); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 59:309-311, pl. 22, figs. 3, 6 (Note: Plate mislabeled); Kaston, 1938, Canad. Entomol., 70:16, fig. 10; Kaston, 1948, Bull. Connecticut Ecol. Nat. Hist. Survey, 70:310-311, pl. 49, figs. 987-988, pl. 50, fig. 1005, pl. 51, fig. 1011.

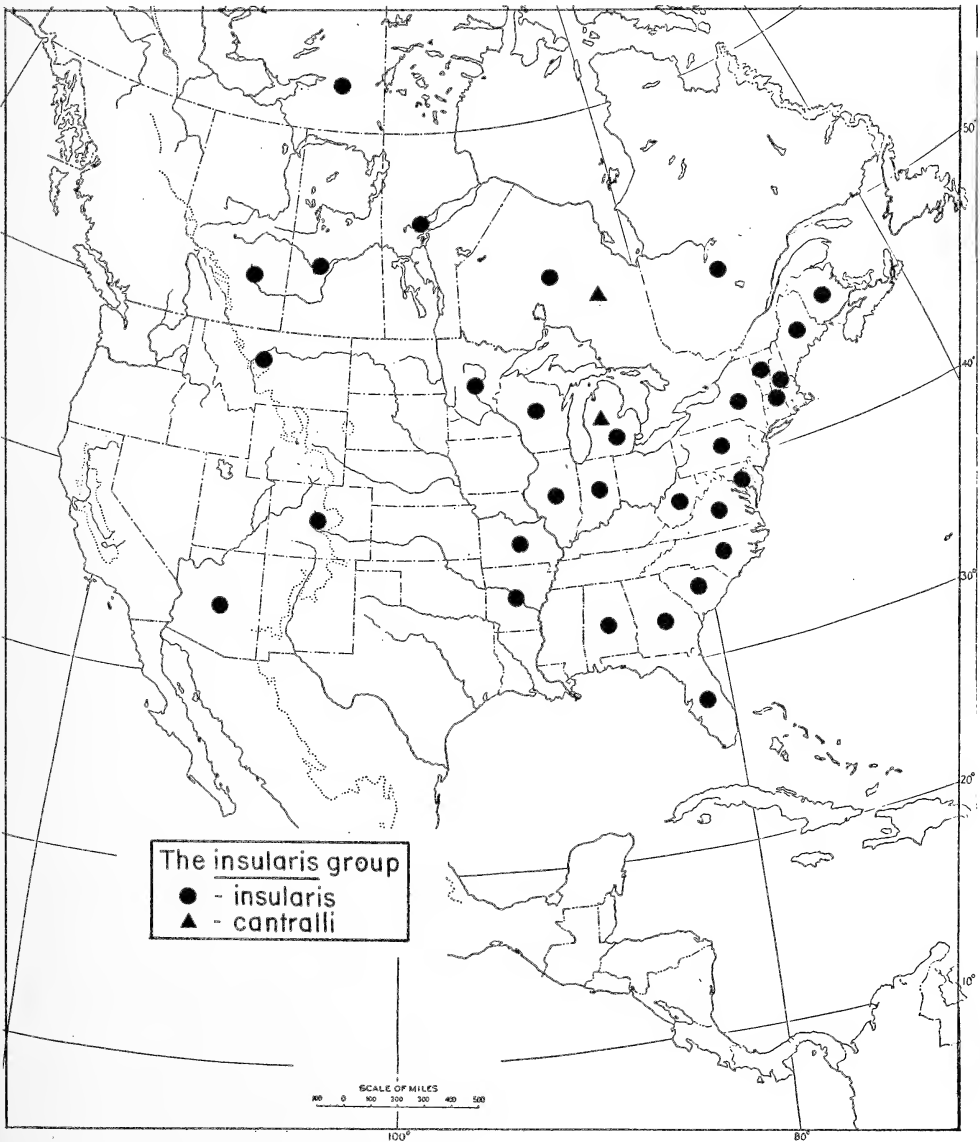
Pardosa bilobata Tullgren, 1901, Bih. Svenska Vet.-Akad. Handl., 27 (4,1):22, fig. 12 (2 females, Lake Leonore, Florida; Zool. Inst., Uppsala, examined); Chamberlin, 1908, *Ibid.*, 315.

Pirata liber Montgomery, 1902, Proc. Acad. Nat. Sci. Philadelphia, 54:578-579, pl. 30, figs. 42-43 (male, female, Philadelphia, Pennsylvania; A.M.N.H., examined).

Pirata sylvestris Emerton, 1909, Trans. Connecticut Acad. Arts and Sci., 14:209, pl. 6, figs. 8, 8a (male, not the female, Lynn Woods, (?) Massachusetts; M.C.Z., examined).

See remarks under *P. piraticus*.

Description of lectotype.—A somewhat faded female with submarginal light band and the usual tuning-fork pattern on the carapace which is 3.3 mm long and 2.5 mm wide (Fig. 77). Dorsum with distinct hastate mark and no indication of white patches of scales as in *P. piraticus*. Basic color of body and legs amber; legs not banded. Venter much lighter than sides of abdomen with longitudinal streaks of pigment. Sternum with a median longitudinal light area. Epigynum (Fig. 78).



Variation.—*P. insularis* is a variable species both in size and pigmentation; usually, however, the submarginal light band pattern on the carapace is discernable. Males range in length of carapace from 1.7 to 2.7 mm; females from 1.9 to 2.8 mm. Sometimes the hairs on tibia and metatarsus I of the male are long and dense and could be mistaken for the brush in *P. cantralli*; however, the tibia is not swollen like in *P. cantralli*.

A small (carapace 1.7 mm long, 1.2 mm wide) amber-colored male, with no pattern, from Temiskaming, Quebec, may be new. The palp is very similar to *P. insularis* and leg I is not swollen like in *P. cantralli*.

Eight females from Holliston, Massachusetts, 17-30 June, J.H.E. and N.B., coll., identified as *P. sylvestris* are in two sizes. The large ones, carapace 2.4 mm long, are heavily sclerotized. The small ones, carapace 1.9 mm long, are lightly sclerotized.

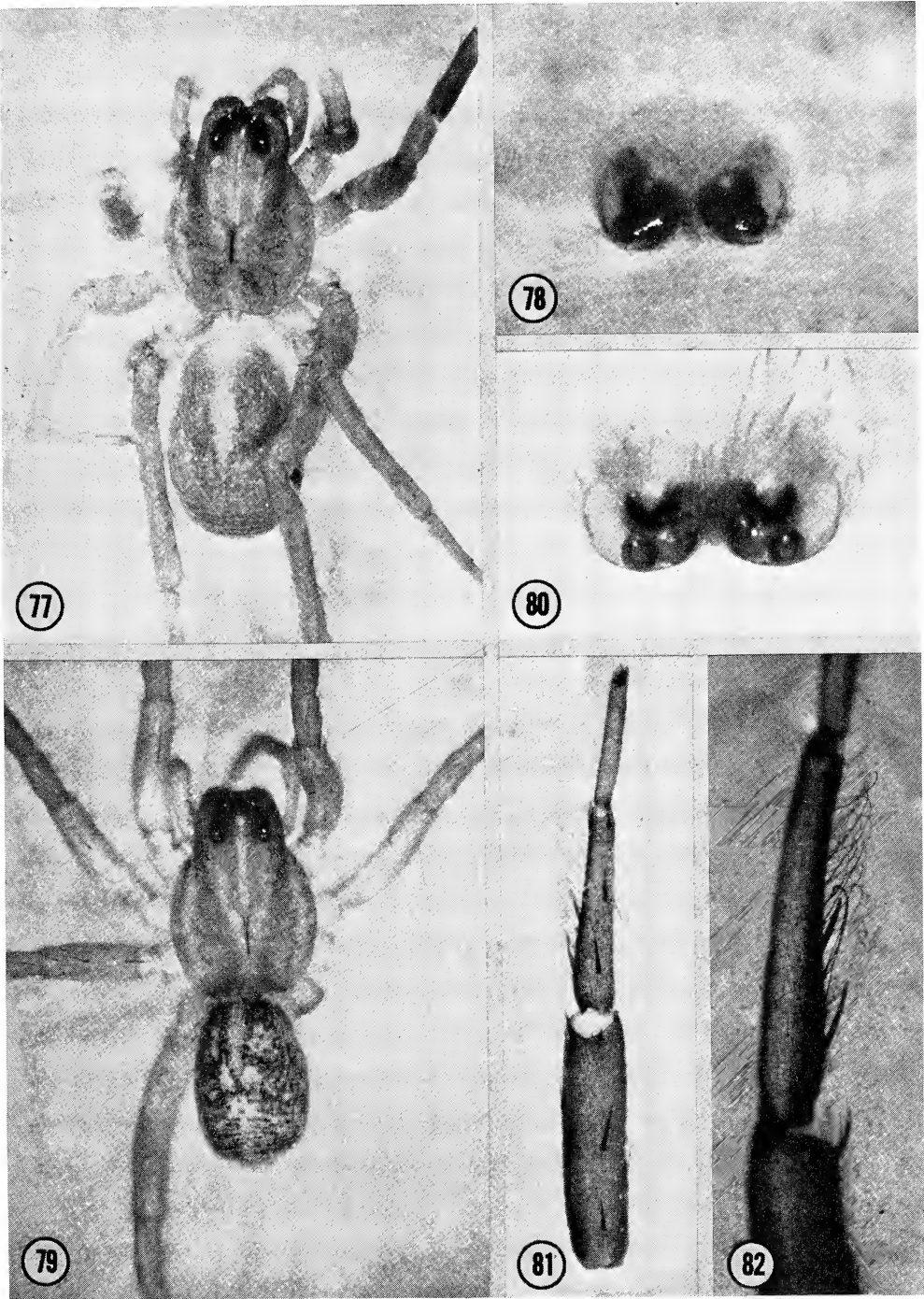
Distribution.—Southern Canada and the U.S. east of the Rocky Mountains.

Specimens examined.—Canada: *Alberta*: George Lake; *Manitoba*: Darwin; New Brunswick; *Northwest Territory*: Gt. Slave Lake; *Ontario*: 26 localities; *Quebec*: E. shore of James Bay; Temiskaming; *Saskatchewan*: Lady Lake, Besnard Lake, Lac La Rouge.

United States: *Alabama*: Jackson, Mobile Counties; *Arizona*: White Mt. Res. E. of McNary; *Arkansas*: Mississippi County; *Colorado*: Larimer County; *Connecticut*: Fairfield County; *Florida*: Alachua, Collier, Dade, Escambia, Gadsden, Hernando, Highlands, Jackson, Jefferson, Lake, Lee, Levy, Liberty, Marion, Nassau, Orange, Pasco, Pinellas, Polk, Putnam, Sarasota, St. Johns Counties; *Georgia*: Burke, Rabun, Screven, Thomas Counties, Okefinokee Swamp; *Illinois*: Lake, McHenry, Sangamon Counties; *Indiana*: LaPorte, Potter, Smith Counties; *Iowa*: Clinton County; *Maine*: Penobscot, York Counties; *Maryland*: Baltimore, Montgomery Counties; *Massachusetts*: Barnstable, Middlesex Counties; *Michigan*: Arenac, Barrien, Calhoun, Cheboygan, Clinton, Douglas, Emmet, Gogebic, Ingham, Johnson, Kalamazoo, Keeweenaw, Livingston, Macomb, Marquette, Menominee, Midland, Muskegan, Oakland, Ontonagon Counties; *Minnesota*: Itaska Park; *Missouri*: Crawford, Johnson Counties; *Montana*: Carbon County; *New Hampshire*: Fitzwilliam; *New Jersey*: Bergen, Burlington Counties; *New York*: Albany, Cattaraugus, Hamilton, Nassau, Queens, Rensselaer, Saratoga, Schuylar, Tompkins, Wayne Counties; *North Carolina*: Carteret, Durham, Swain Counties; *Ohio*: Fairfield, Fulton, Hocking, Knox, Ottawa Counties; *Pennsylvania*: Allegheny, Cambria, Franklin, Lancaster, Westmoreland Counties; *South Carolina*: Aiken County; *Tennessee*: Roane County; *Vermont*: Groat; *Virginia*: Arlington, Giles, Nansemond, Page, Surry Counties; *West Virginia*: Pocahontas County; *Wisconsin*: Ashland, Barron, Dane, Iron, Langlade, Taylor, Waukesha Counties.

Life history.—In the Gainesville, Florida, region this species matures in the spring (February, March, April, May). By June the species has dwindled to occasional individuals which may be found throughout the remainder of the year until the next spring. We have adults from every month but January, and no records of adult males after June. In the Gainesville region females with egg sacs have been taken during April, May and June. In south Florida females have been taken in March, April and December.

As we move northward from Florida our records indicate a progressively later season of maturity and breeding. We have no record of adult males from earlier than May from either the southeastern states (Arkansas, Louisiana, Mississippi, Alabama, Georgia, Kentucky, Tennessee, West Virginia, North Carolina, South Carolina, Maryland, Delaware) or northeastern states (Wisconsin, Illinois, Michigan, Indiana, Ohio, Pennsylvania, New Jersey, New York, Vermont, New Hampshire, Maine, Massachusetts, Connecticut). For both the southeast and northeast the majority of our records are from May, June and



Figs. 77-80.—*P. insularis*: 77, lectotype female, New York, Long Lake, 1884; 78, lectotype epigynum; 79, female, Michigan, Livingston Co., E.S.G.R., H.K.W. 1789H; 80, epigynum, Florida, Pinellas Co.

Figs. 81-82.—*P. cantralli*, n. sp.: 81, leg I, Michigan, Livingston Co., E.S.G.R.: 82, metatarsus I, Michigan, Livingston Co., E.S.G.R., H.K.W. 1796E.

July with the number of records falling off in the northeast as winter approaches while there are only a total of five records for the southeast after July: a male and female from August and a male and two females from December. Data from the western states indicate a seasonality similar to the northeastern states while the Canadian data indicate the attainment of maturity about a month later.

We have records of egg sacs from the southeast from April, May and June; for the northeast from June, July, August and September; for the west from July and September; and for Canada from July and September.

Looking at the country as a whole we have males from every month except November and January, females from every month, and egg sacs from every month except January, February and November.

Pirata insularis matures at different times in the spring in different localities in the Gainesville, Florida, region. Thus, *P. insularis* will be mature in one spot during February, and immature at the same time in various other localities in the region. It is the species of *Pirata* most commonly found in the Gainesville region.

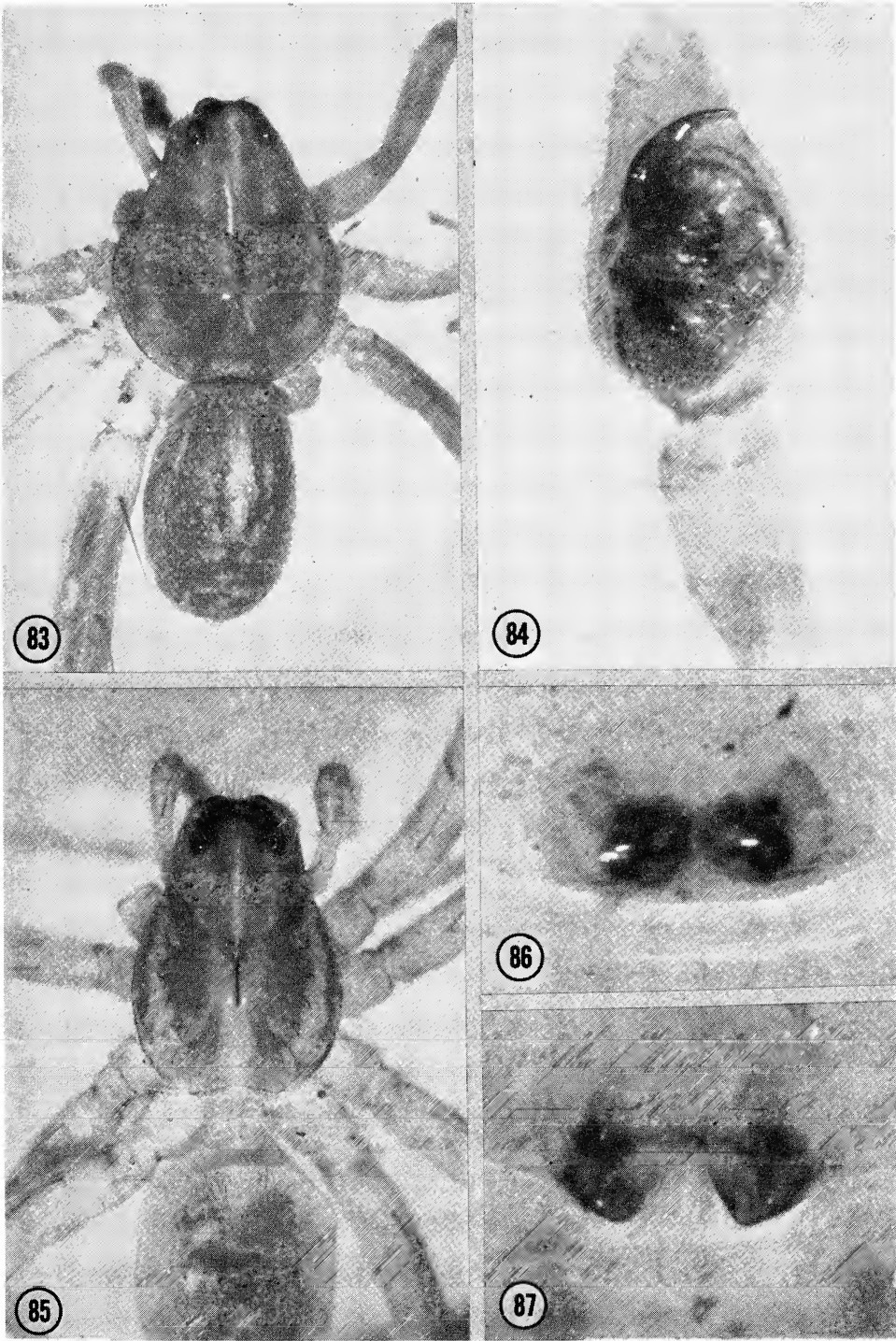
Ecology.—In the Gainesville, Florida, region this species apparently occurs in all kinds of moist situations except typical flatwoods. It occurs in wet situations in various types of hammocks, in swamps, and in the vegetational mattings of some of our marshes and all of our lakes. Records from other regions indicate that it is an inhabitator of marsh, and the edges of ponds and streams throughout its range. In Michigan it also occurs in bogs and swamps. It sometimes occurs in the same bog or marsh as *P. cantralli*, but our evidence indicates that these two species do not occupy the same niche. For example, in the “Big Cassandra” on the George Reserve in Michigan *P. insularis* was collected from sphagnum moss out in the leatherleaf bog proper while *P. cantralli* was taken around the edge of the Cassandra on mud flats covered with a dense growth of tiny moss plants.

In Stone-Ring Marsh on the Reserve *P. cantralli* appeared to be most numerous in zones of emergent vegetation while *P. insularis* was taken in wet zones where there was no standing water. *P. insularis* occurs in sphagnum whether it be in marsh or swamp.

Remarks.—Montgomery’s types of *P. liber* are now in the American Museum of Natural History and the male is labeled holotype and the female allotype. The carapace of the male is 2.20 mm long, 1.80 mm wide; of the female is 2.35 mm long, 1.67 mm wide (Figs. 83, 85). His figures of the genitalia are recognizable and he considers his specimens to be distinct from *P. insularis* (Figs. 84, 86).

Six males and 24 females of *P. insularis* were checked for the number of apical spines on the ventral surface of tibia I and II. All the males had pairs on tibia I and II. The data for females follows:

Combination	Tibia I		Tibia II		Number Cases
	Right	Left	Right	Left	
1	0	0	1	1	5
2	1	1	2	2	4
3	2	2	2	2	2
4	0	1	1	1	1
5	0	0	0	1	1
6	1	1	1	1	2
7	1	1	1	2	2
8	1	1	2	1	1
9	0	0	0	0	1
10	1	2	2	2	1
11	1	1	1	0	1
12	0	1	2	2	1
13	1	0	1	1	1



Figs. 83-86.—*P. liber* Montgomery (= *P. insularis*): 83, male type, Pennsylvania, Philadelphia; 84, male type, palp; 85, female type, Pennsylvania, Philadelphia; 86, female type, epigynum.
Fig. 87.—*P. mayaca*: Allotype, epigynum, Florida, Port Mayaca.

In Michigan *P. insularis* and *P. piraticus* were collected together in a cat-tail marsh on muddy ground; they were collected together on numerous occasions in marshy situations. On the other hand, sometimes *P. insularis* was the only *Pirata* collected.

In 1954 Wallace, while working on the Edwin S. George Reserve near Pinckney, Michigan, collected a marsh by vegetational zones and found that *P. insularis* and a very similar species, here described as *P. cantralli*, appeared to occupy different, but contiguous zones. Females are indistinguishable as are the palpi and epigyna, but the male of *P. cantralli* has swollen legs I and II and a conspicuous brush of hair-like structures on metatarsus I. Males with swollen front legs and brushes on the metatarsi have been collected in three other counties in Michigan, in Wisconsin, and in Ontario.

***Pirata cantralli*, n. sp.**

Figs. 81-82, 88-89

Holotype.—Male, Michigan, Livingston Co., E. S. George Reserve, M-28, VII.15.54, HKW 1789E (M.C.Z.).

Allotype.—Female with same data (M.C.Z.).

Etymology.—Named after Irving J. Cantrall, who was resident naturalist on the Edwin S. George Reserve and who accompanied Wallace on many collecting trips and helped the spider work in many ways.

Diagnosis.—*P. cantralli* is very similar to *P. insularis* except for swollen legs I and II and the brush on metatarsus I of *P. cantralli*. Their genitalia, size, and appearance, except for legs I and II in the male, appear to be identical.

Description of holotype.—Carapace 2.4 mm long, 1.75 mm wide, with a distinct submarginal light band and distinct tuning-fork mark on the head. The submarginal band is slightly wavy laterally and has three distinct indentations medially. Basic color of body a light amber in alcohol. Dorsum with the usual hastate pattern and faint indications of paired small round white spots produced by scales. Coxae, labium and endites light yellow, covered with numerous short hair-like structures. Sternum slightly dusky with a median light area and covered with longer hair-like structures. Epigastric region light, venter a little darker. Lower margin of the furrow of the chelicerae with three evenly spaced teeth, the middle tooth the largest. Anterior eye row slightly procurved, narrower than posterior median eye row; anterior median eyes equal one and one-half times anterior lateral eyes; anterior eyes about equally spaced. Clypeus equals diameter of anterior median eyes.

Legs 4132, without annulae. Legs I and II swollen and heavily sclerotized; metatarsus I with a ventral brush of hair-like structures which are curled at their tips (Figs. 81-82). A few of these curled hairs also occur on the tarsus. Tibiae I and II with three pairs of non-overlapping ventrolateral spines, the distal pair apical; most of these spines, stout, but the proximal prolateral spine on tibia II is reduced to less than half the size of the retrolateral; a prolateral spine is present on tibia I between the middle and apical spines.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.83	0.43	0.43		0.78	2.47
Leg I	1.80	0.78	1.45	1.32	0.80	6.15
Leg II	1.65	0.70	1.25	1.28	0.72	5.60
Leg III	1.62	0.70	1.18	1.50	0.70	5.70
Leg IV	2.22	0.78	1.93	2.50	1.03	8.46

Metatarsi I and II with three pairs of stout, non-overlapping ventrolateral spines plus a third distal spine on the midline between the distal pair; none of the distal spines are apical in position. For palpus see Figs. 88 and 89.

Description of allotype.—Carapace 2.5 mm long, 1.77 mm wide; color and pattern similar to the male except for venter which is more heavily pigmented and punctate. Eye arrangement similar to male. Lower margin of furrow of chelicerae with three unevenly spaced teeth, the middle tooth the largest.

Legs 4132, without annulae. Tibia I with two pairs of ventrolateral spines, the proximal pair overlapping base of middle pair; and two prolateral spines, one apical, one between middle pair and the apical spine. Metatarsus I with three pairs of ventrolateral

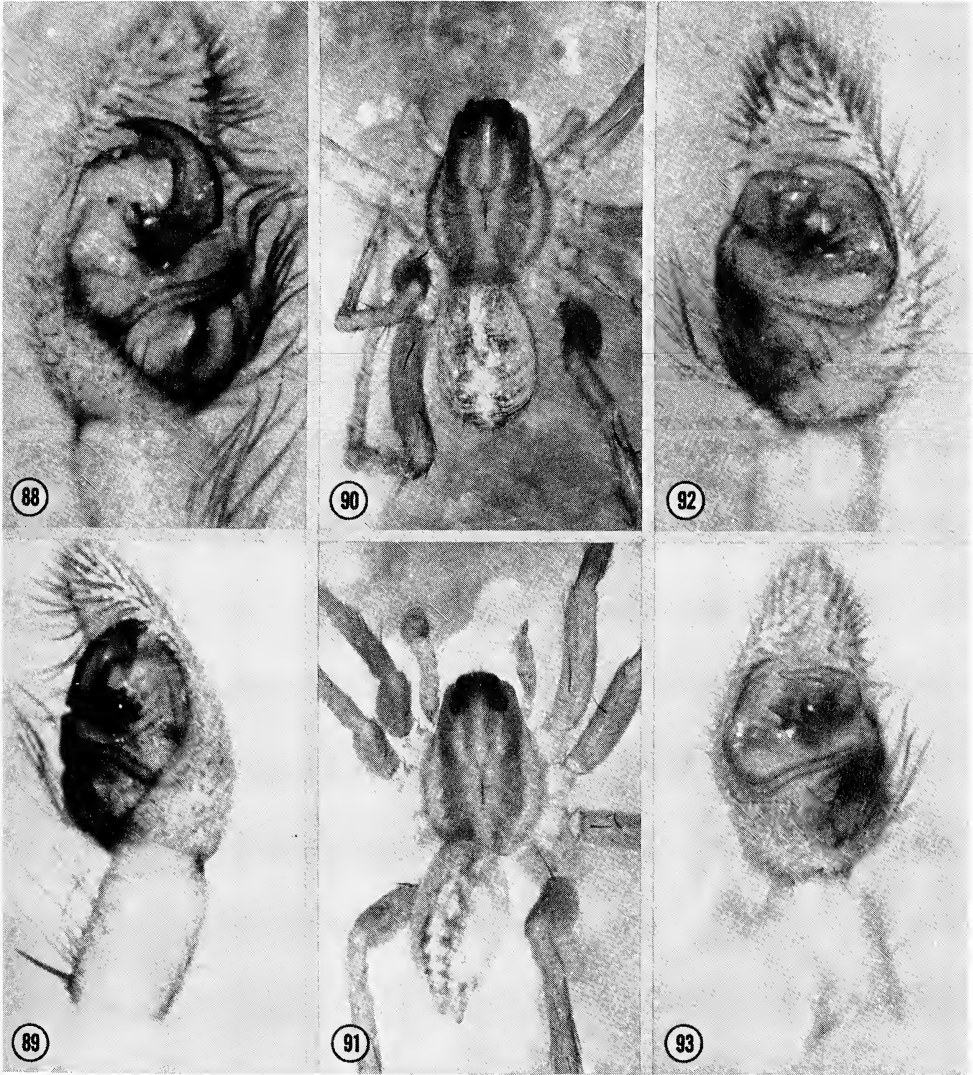


Fig. 88.—*P. cantralli*, n. sp.: Palp, Michigan, E.S.G.R., H.K.W. 1789E.

Fig. 89.—*P. cantralli*, n. sp.: Palp, Michigan, E.S.G.R., H.K.W. 1448.

Figs. 90-93.—*P. mayaca*: 90, allotype female, Florida, Port Mayaca; 91, holotype male, Florida, Port Mayaca; 92, palp, Florida, 50 mi. west of Miami; 93, holotype, palp.

spines, the proximal pair overlapping base of middle pair, the distal pair subapical in position. Tibia II with five ventral spines, the distal one apical, the medial of each pair much reduced, the proximal much more so than the middle. Metatarsus II with three pairs of spines and a seventh spine between the subapical distal pair.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.87	0.42	0.50		0.75	2.54
Leg I	1.87	0.80	1.45	1.42	0.75	6.29
Leg II	1.70	0.75	1.30	1.32	0.70	5.77
Leg III	1.65	0.70	1.22	1.57	0.68	5.82
Leg IV	2.24	0.87	1.93	2.50	0.97	8.51

Variation.—*P. cantralli* appears to be a rather uniform species; lightly sclerotized specimens are paler in color than heavily sclerotized ones, but this is true of all arthropods. The male from Ontario has swollen front legs, but the brush on metatarsus I is not as conspicuous as in Michigan specimens.

Distribution.—Ontario and Michigan.

Specimens examined.—Canada: *Ontario*: Sproule Bay, Lake Opeonga, Alg. Pl., June 26-July 7, 45, W 78° 22', N 45° 38', male, four females (R.O.M. 7817); United States: *Michigan*: Calhoun County: Tekonsha, 30.V.42, A.M.C., male (M.C.Z.); Clinton County: Bath, 14-24, July 66, DEB 59, male, female (D.E.B.); Kalamazoo County: Gull Lake, 1-7 July 1965, D.E.B., male (D.E.B.); Gull Lake Biol. Sta., 22 June-9 July 65, T.F.H., pitfall trap, *Typha* marsh, male, 2 females (D.E.B.); Gull Lake Biol. Sta., 15-22 July 65, female (T.F.H.); Gull Lake Biol. Sta., 29 July-4 Aug 65, male, 2 females (D.E.B.); Gull Lake Biol. Sta., 4-11 Aug 65, male (D.E.B.); Livingston County: E.S. George Reserve, D6-8, VI.19.51, HKW 1410, 2 males, 2 females (HKW); M-28, VII.3.51, HKW 1448, 3 males, 7 females with egg sacs (HKW); P-18, VII.4.51, F.N. Young, male (HKW); M-28, VII.14.54, HKW 1788, 1 male, 9 females (HKW); M-28, VII.14.54, HKW 1788A, male, four females (HKW); R-6, VII.30.54, HKW 1819, male, 6 females (HKW); M-28, VII.19.54, HKW 1796E, 3 males, 9 females, imms., egg sac (HKW); M-28, VII.19.54, HKW 1796H, male, 5 females, egg sac (HKW).

Life history.—We have examined males from May, June, July and August, females from June, July and August, and egg sacs from July. Wallace's records from Michigan were limited to the three months (June, July, August) he spent on the Reserve each of three summers. Adults probably are present over a longer period than that indicated above.

Ecology.—As stated in the discussion under *P. insularis*, *P. cantralli* appears to occur in emergent vegetational zones in marshy and in other situations in bogs, but not in the same niches as *P. insularis*. These conclusions are tentative and need careful checking.

THE MAYACA GROUP

Pirata mayaca Gertsch

Figs. 87, 90-96

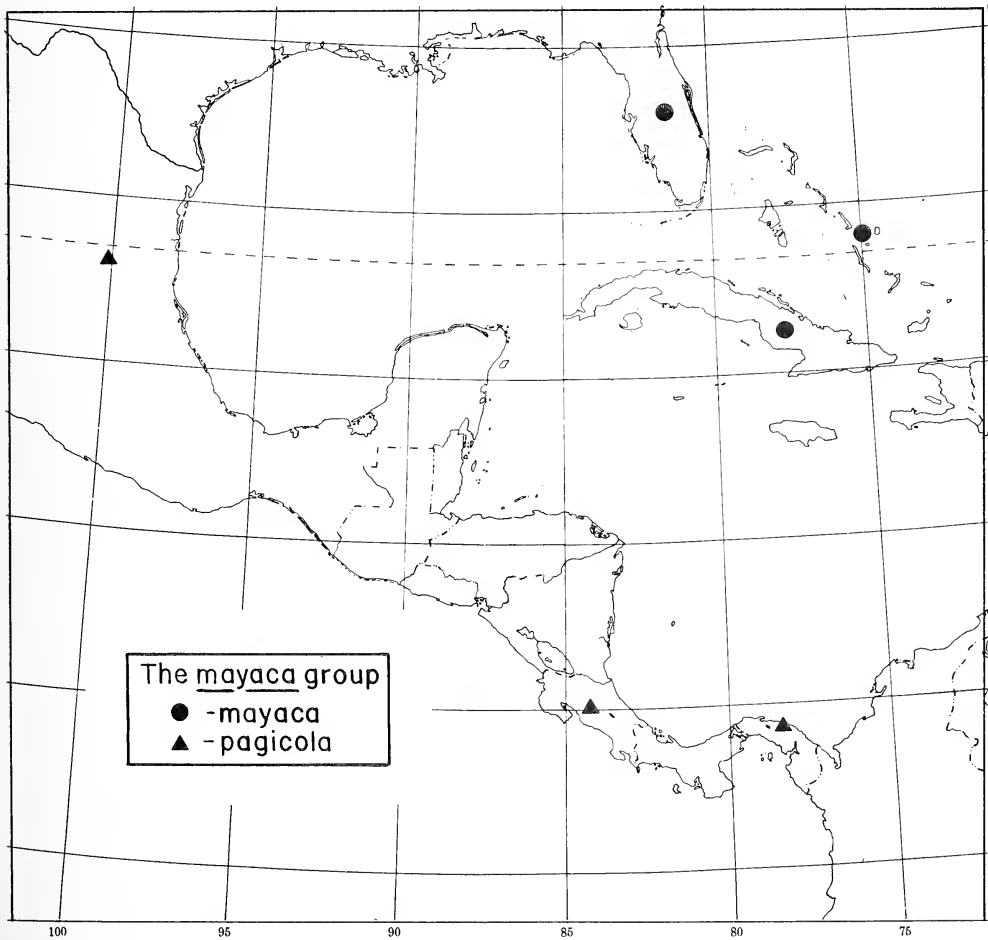
Pirata mayaca Gertsch, 1940, Florida Entomol., 23(2):21-22, figs. 5-6 (male, female, Port Mayaca, Florida, A.M.N.H., examined).

Pirata gertschi Chamberlin and Ivie, 1944, Bull. Univ. Utah, 35(9):149-150, figs. 190-191 (male, female, 3 mi SE Savannah, Georgia, not examined. See remarks). NEW SYNONYMY.

Description of holotype.—A male with carapace 1.8 mm long, 1.3 mm wide, with a wide submarginal light band (Fig. 91). Legs not banded. Dorsum with a distinct pattern of four triangular white markings on the midline with their apices pointing anteriorly. Anterior eye row narrower than the posterior median row, almost straight; anterior median eyes twice as large as anterior lateral eyes, closer to anterior lateral eyes than to each other. Clypeus equals 4/5 the diameter of anterior lateral eyes. Tibiae I and II with three pairs of spines, the distal pair apical in position. The distal process of the median apophysis of the male palp is long and recurved (Fig. 93).

Description of allotype.—Carapace with a submarginal light band not as wide as in the holotype and a distinct tuning-fork pattern (Fig. 90). Legs unbanded. Eye arrangement similar to male. Tibiae I and II with two pairs of ventral spines. Epigynum (Fig. 87) somewhat similar to that of *P. aspirans*.

Description of male from Palm Beach Co., Florida.—U.S. Sugar Corp., Sand Cut, Pitfall, 31-VII.70, Carapace 1.62 mm long, 1.28 mm wide, with a submarginal light band with very irregular borders and a distinct tuning-fork pattern on the head. Dorsum with large light hastate mark and irregular pattern posteriorly. Sternum, coxae, venter yellow, immaculate. Lower margin of the furrow of chelicerae with three teeth, middle tooth the largest, lateral tooth the smallest. Anterior eye row narrower than the posterior median



row, procurved; anterior median eyes are twice as large as the anterior lateral eyes, closer to anterior lateral eyes than to each other. Clypeus height somewhat less than the diameter of an anterior median eye. Tibia I with three pairs of ventral spines, the distal pair apical in position. Tibia II with three pairs of ventral spines, the distal pair apical in position; the prolateral spines much reduced in size. Legs 4123, unbanded.

Description of a female paratype.—Port Mayaca, Fla., March 28, 1938., W. J. Gertsch, coll. Carapace 2.00 mm long, 1.50 mm wide, with a submarginal light band with irregular borders and a distinct tuning-fork pattern on the head. Dorsum with a light hastate mark and irregular dark, crease-like pattern behind. Sternum, coxae, venter yellow, immaculate. Lower margin of furrow of chelicerae with three teeth, evenly spaced, the middle tooth the largest. Anterior eye row slightly narrower than the posterior median row, almost straight, eyes about equally spaced, anterior median eyes twice as large as the anterior laterals. Clypeus receding, equal in height to the diameter of an anterior lateral eye. Tibia I with two pairs of long ventral spines and one prolateral apical spine. Tibia II with two pairs of ventral and one prolateral apical spine; the prolateral spines much reduced in size. Legs 4123, unbanded.

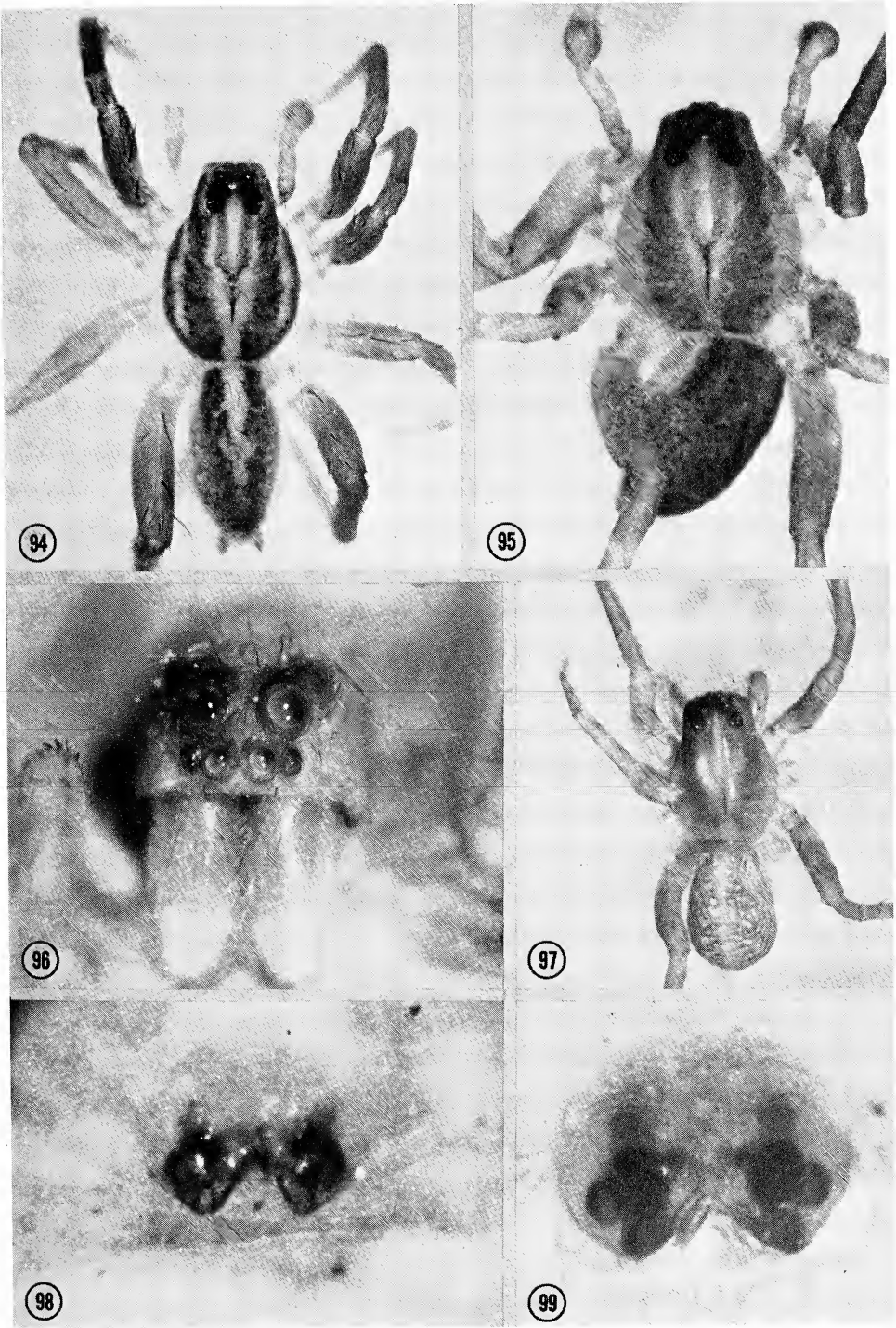
Distribution.—Florida, British West Indies, Cuba. Females from North Carolina and Cuba resemble *P. mayaca*, but males are needed to verify these records.

Specimens examined.—*British West Indies*: Crooked Island, S.E. of Gordon Bluff, Sept. 58, A. W. Scott, Jr., 1 male (M.C.Z.); *Cuba*: Trinidad Mts., Buenos Aires, 9 May 36, P. J. Darlington, 3 females (M.C.Z.); Soledad, Mar 1925, Salt and Mayers, female (M.C.Z.); United States: *Florida*: Royal Palm Park, 15-24 Mar 1930, Blatchley, male (M.C.Z.); Alachua County: II-2-37, HKW Sta 6c, male (H.K.W.), IV-19-37, HKW Sta 1, female (H.K.W.), VI-14-37, HKW 15, male (H.K.W.); Dade County: 2-5 mi. S. Florida City, April 1, 1957, Forester and Gertsch, female (A.M.N.H.), 50 mi. W. Miami, March 31, 1957, Forester and Gertsch, male (A.M.N.H.); Flagler County: 14.8 mi. S.E. County Line on Fla 28, IV-1-39, HKW 1073, male, 2 females (H.K.W.); (?) Franklin County: nr. Sebring, Highlands Hammock, Mar 24, 1938, Gertsch, female (A.M.N.H.), Archbold Bio. Sta., Feb., Neofiber burrows, female (A.M.N.H.); Indian River County: Sebastian, II-44, Nelson, female (M.C.Z.); Lee County: 6.3 mi. S. Ft. Myers on U.S. 41, 15 Apr 49, HKW 1306, male, 2 females (H.K.W.); Levy County: 6 mi. E. of Cedar Keys, IV-9-37, HKW 593, 1 male, 1 female (H.K.W.); Martin County: Port Mayaca, Lake Okechobee, May 29, 1938, 3 males, 14 females (Holotype, allotype, paratypes, A.M.N.H.; 1 male, 3 female paratypes, H.K.W.); Palm Beach County: Canal Point, 8-V-70, pitfall, male (D.P.I.); Putnam County: U.F.C.R., VI-1-47, H.K.W. 1264, male, female (H.K.W.).

Life history.—All of the records for *P. mayaca* but one are from spring and early summer; males from February through June, females February through May. The exception is the male from Crooked Island in September.

Ecology.—The information available indicates that this species always occurs near water.

Variation.—Males vary in carapace size from 1.5 mm long, 1.0 mm wide to 1.8 mm long, 1.3 mm wide; females from 1.4 mm long, 1.0 mm wide to 2.2 mm long, 1.6 mm wide. In Florida this species has a submarginal band on the carapace, but in the three females from the Trinidad Mountains in Cuba the pattern varies from light to medium dark with a wide marginal light band on the carapace and faint annulae on the legs; one of these has indications of marginal pigment. The carapaces of these three females measure 2.05 mm long, 1.55 mm wide; 2.0 mm long, 1.45 mm wide; 2.0 mm long, 1.50 mm wide.



Figs. 94-96.—*P. mayaca*: 94, male, Florida, Palm Beach Co.; 95, male, British West Indies, Crooked Island; 96, male, eyes, Florida, Putnam Co.
Figs. 97-99.—*P. pagicola*: 97, holotype female, Barro Colorado Island; 98, holotype, epigynum; 99, epigynum, Mexico, Tamaulipas, Rancho del Cielo.

The male from Crooked Island, British West Indies, has a carapace measuring 1.7 mm long, 1.3 mm wide. Wallace noted that it had a submarginal band on the carapace and distinct annulations on the legs, but a photograph of the specimen makes it appear to have a wide marginal light band and indistinct annulae.

Remarks.—The median apophysis of *P. mayaca* is quite distinctive and males can be identified with certainty. Females, on the other hand, are hard to identify and any locality record based on females should be considered tentative until confirmed by collection of males.

Remarks.—Dr. Cooke wrote that he was unable to locate the types of *P. gertschi* in the A.M.N.H. so they may be lost. The figure of the epigynum of *P. gertschi* does not represent anything we have seen, but the figure of the palp is that of *P. mayaca*; only *P. mayaca* in Georgia has the recurved distal arm of the median apophysis.

This species has been identified as *P. felix* by various authors. The type of *P. felix* is a smaller spider with a much different epigynum (Fig. 109).

P. pagicola and *P. mayaca* have very similar genitalia, but differ in size and pattern. *P. mayaca* has a submarginal band on the carapace, but in *P. pagicola* it is marginal. *P. mayaca* is much smaller than *P. pagicola*.

The specimens listed as *P. mayaca* from Cuba and the British West Indies have the pattern of *P. pagicola* and size of *P. mayaca*.

Pirata pagicola Chamberlin

Figs. 97-104

Pirata pagicola Chamberlin, 1925, Bull. Mus. Comp. Zool., 67(4):225 (female, M.C.Z., 1,292, Barro Colorado Island, examined).

Pirata felix Gertsch and Davis, 1940, Amer. Mus. Nov., 1059:9-10, examined. NEW SYNONYMY.

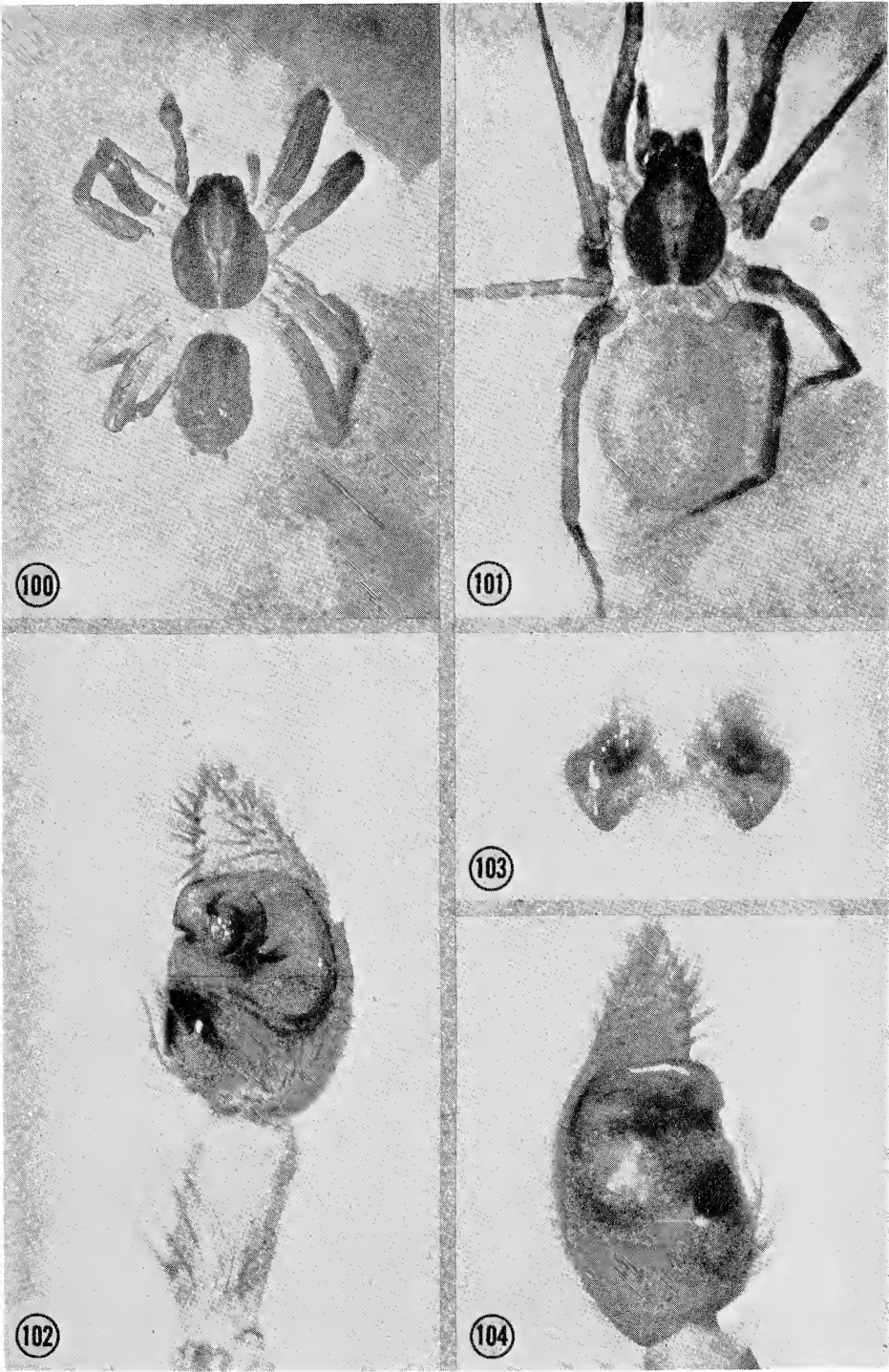
Remarks on the holotype.—Chamberlin's description still fits the specimen. Carapace 1.9 mm long, 1.3 mm wide, with a wide marginal light band, but it looks like it might be interpreted as a submarginal band. The anterior eye row is slightly narrower than the posterior row, almost straight; anterior eyes evenly spaced, anterior median eyes are twice as large as the anterior laterals.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Leg I	1.40	0.63	1.17	1.17	0.55	4.92
Leg IV	1.75	0.70	1.75	1.90	0.90	7.00

Chamberlin did not figure the epigynum (Fig. 98) which resembles *P. aspirans* and *P. mayaca*. The palpi of *P. mayaca* and *P. pagicola* are very similar and differ from *P. aspirans*.

Distribution.—Panama: Barro Colorado Island; México: Tamaulipas, Veracruz, and San Luis Potosí; Costa Rica.

Specimens examined.—Costa Rica: Turrialba, I.I.C.A., 13 Mar 67, W. Peck, ground, opening in jungle, female (Exline). México: San Luis Potosí: 5 mi. N. Tamazunchale, July 2, 1936, L. I. Davis, female (A.M.N.H.); San Luis Potosí, Picolo, May 21, 1952, W. J. G., 4 males, 10 females (A.M.N.H.); Tamaulipas: Rancho del Cielo, 6 mi. N.W. Gómez Farías, 9 Mar 1969, J. Reddell etc., male, female (A.M.N.H.), Mar 24, 1967. R. W. Mitchell. 3



Figs. 100-104.—*P. pagicola*: 100, male, Mexico, Tamaulipas, Rancho del Cielo; 101, female, Mexico, Tamaulipas, Rancho del Cielo; 102, palp, Mexico, San Luis Potosi, May 21, 1952, W.J.G.; 103, epigynum, Mexico, San Luis Potosi, May 21, 1952, W.J.G.; 104, palp, Mexico, Tamaulipas, Rancho del Cielo.

females and egg sac (A.M.N.H.); Rancho del Cielo, 4200 ft., 5 females (A.M.N.H.); Veracruz: nr. Jalapa, Aug 1948, C. Goodnight, female (A.M.N.H.).

Life history.—We have examined males from March and May, females from March, May and July.

Ecology.—The only information we have is from a label, “ground-opening in jungle.”

Variation.—Five females from Tamaulipas have dark carapaces like *P. montanus*. A male has a carapace 2.3 mm long, 1.7 mm wide, a female 2.5 mm long, 1.8 mm wide. The male also has a carapace like *P. montanus*.

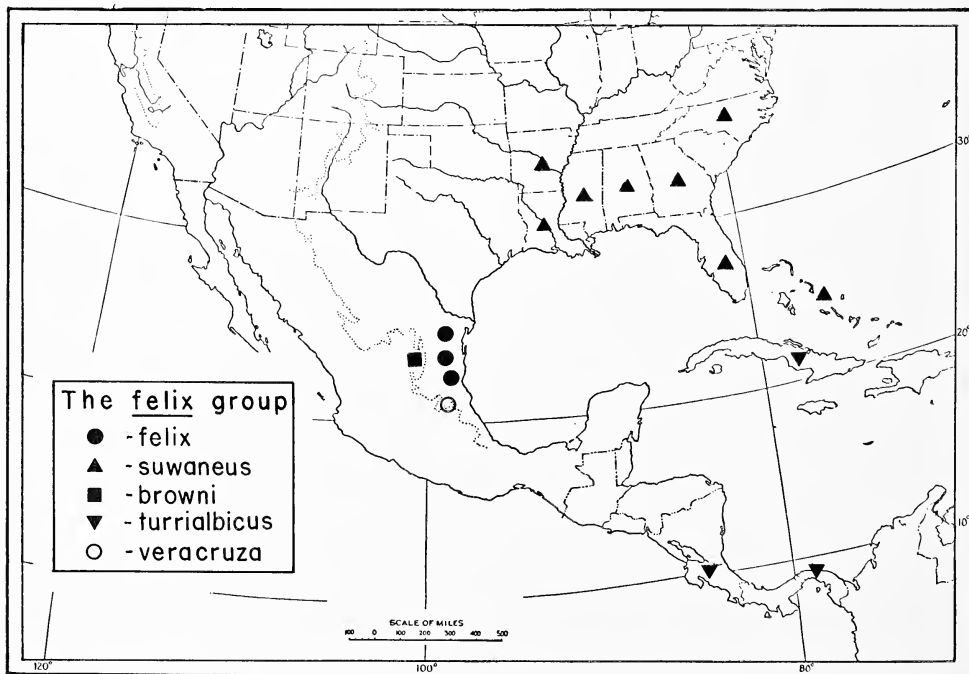
The spinning on tibia I and II in *P. pagicola* and *P. mayaca* is similar.

THE FELIX GROUP

The following species are very similar in appearance, genitalia and size and as a result are very difficult to separate: *P. felix*, *P. suwaneus*, *P. browni*, *P. veracruzae*, and *P. turrialbicus*, n. sp. *P. browni* and *P. suwaneus* have a submarginal light band on the carapace; the other three have wide marginal light areas. Unfortunately, the amount of pigment and the transparency of the carapace varies so that, for instance, specimens of *P. turrialbicus* from the same locality vary from very light ones with no annulae on the legs to pigmented individuals with carapace pattern that suggests the presence of a submarginal light area and legs with distinct annulae. So pattern is not always reliable.

Perhaps it is significant that no specimens identified as *P. browni* (Fig. 113) and *P. veracruzae* (Figs. 122-124) have turned up in the collections we have examined. For these two species only the holotypes are known. Both may be heavily pigmented *P. felix*. We propose to let these two species stand pending more thorough collecting in Mexico.

The epigynum of the type of *P. felix* (Fig. 109) appears to us to be identical with that of the allotype of *P. gratus* Gertsch and Davis and the two specimens agree in appearance,



size and morphology. In our opinion they are the same species. *P. turrialbicus* resembles *P. felix* in appearance and morphology, but their genitalia are different (Figs. 105-106, 117-118) and *P. turrialbicus* is a somewhat smaller species than *P. felix*. The palps of *P. felix*, *P. veracruzae* and *P. turrialbicus* are very similar; the palp of *P. felix* is slightly larger than that of *P. turrialbicus* (Figs. 111-112, 120, 123-124). *P. felix* and *P. turrialbicus* have wide marginal light bands or areas, but the lobes of the epigynum are more pointed in *P. turrialbicus*. *P. veracruzae* appears to have a submarginal light band, but the female is unknown.

The type of *P. felix* resembles the allotype of *P. suwaneus* in appearance (Figs. 105, 131) and the epigyna are very similar (Figs. 109, 132). However, we have found no males from Mexico with palpi like Florida *P. suwaneus* and therefore conclude that *P. suwaneus* and *P. felix* are distinct species.

Pirata felix Pickard-Cambridge
Figs. 105-106, 109

Pirata felix Pickard-Cambridge, O., 1898, Biol. Centr.-Amer., Arachn., Aran., 1:243; p. 33, figs. 6, 6a-d (female, Mexico, Atoyac, Vera Cruz, B.M.N.H., examined); Pickard-Cambridge, F., 1902, Biol. Centr.-Amer., Arachn., Aran., 2:330, pl. 31, fig. 23 (female, Guatemala).

Pirata gratus Gertsch and Davis, 1940, Amer. Mus. Nov., 1059:10, figs. 19, 21 (male, female, San Fernando, Tamaulipas, Mexico, A.M.N.H., examined). NEW SYNONYMY

Description of type.—In alcohol the basic color is amber with dark pigmentation producing a pattern on carapace and abdomen and annulae on all legs. Carapace with the usual tuning-fork pattern extending forward between the eyes and a ragged wide marginal light area each side which is invaded medially and laterally by irregular spikes of dark pigment. Dorsum dusky with a light hastate area over the heart, three light chevrons behind the heart region, and a light streak extending posterolaterally on each side from the anterior end of the abdomen. Sternum and coxae light amber colored, venter light with dark pigmentation medially on the posterior half.

Carapace 1.7 mm long, 1.2 mm wide; width of head opposite posterior median eyes 0.7 mm. Posterior ocular quadrangle 0.55 mm wide, 0.32 mm long. Anterior eye row slightly procurved, narrower than posterior median eye row; anterior eyes about equally spaced, anterior median eyes larger than anterior lateral eyes. Clypeus narrow, less than the diameter of an anterior median eye in height.

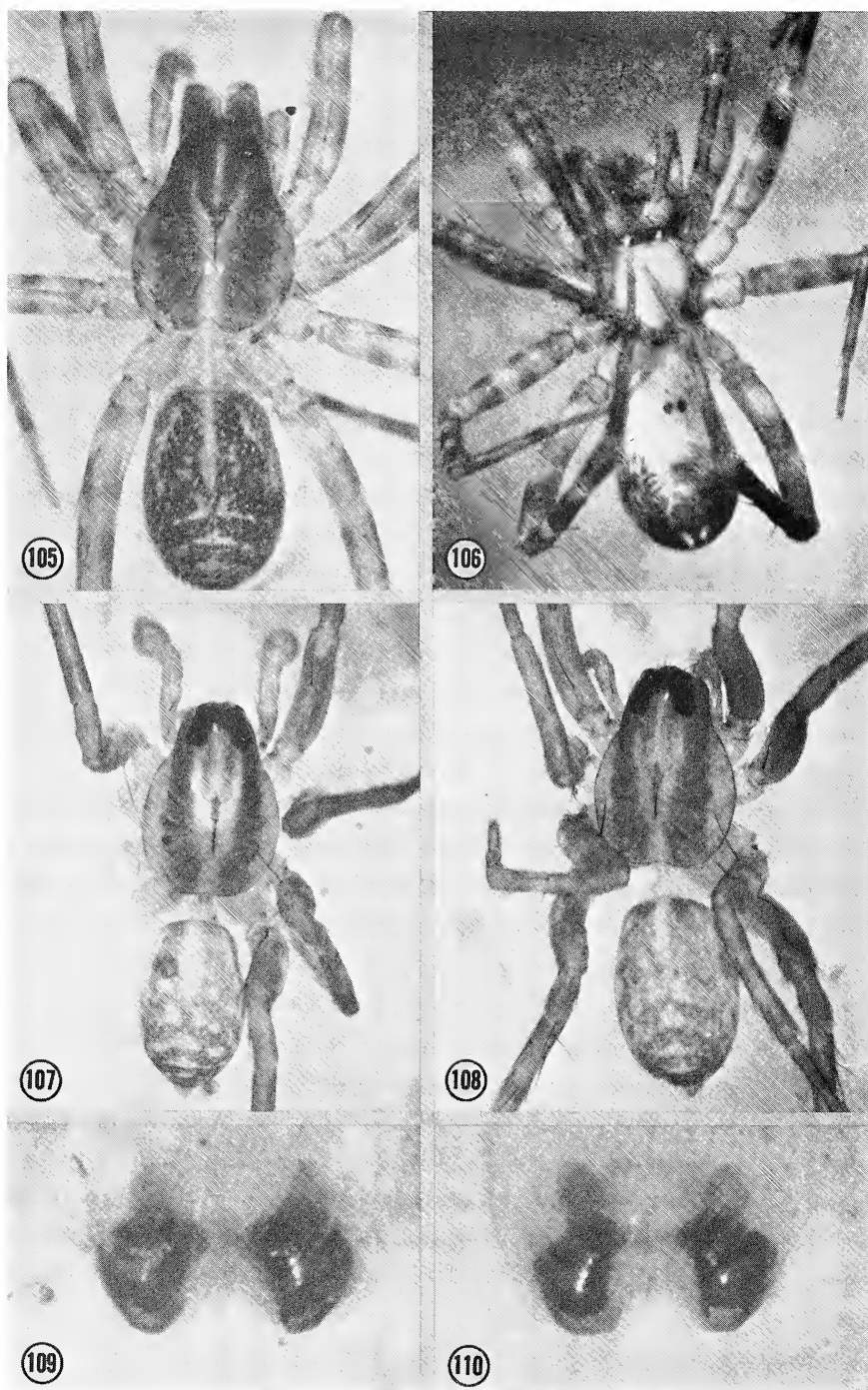
Lower margin of the furrow of chelicerae with three teeth, the one nearest the base of the fang quite small, transparent and inconspicuous; upper margin with three teeth, middle tooth much the largest.

Tibia I with five long overlapping ventral spines, three prolateral, two retrolateral.

Distribution.—México: Tamaulipas, San Luis Potosí, Veracruz.

Specimens examined.—México: *Veracruz*: Atoyac 573, H. H. Smith, female type (B.M.N.H.); *San Luis Potosí*: Apr. 16, 1965, J. Reddell, male (A.M.N.H.); *Tamaulipas*: San Fernando, Mar. 28, 1937, L. I. Davis, male (holotype of *P. gratus* Gertsch and Davis, A.M.N.H.) and male and 5 females (A.M.N.H.); 1 mi. S.W. Villa Juárez, Apr. 17, 1938, L. I. Davis, female (allotype of *P. gratus* Gertsch and Davis, A.M.N.H.).

Ecology.—Nothing has been recorded.



Figs. 105-106.—*P. felix*: 105, female type, Mexico, Vera Cruz; 106, female type, ventral surface.

Figs. 107-108.—*P. gratus* (= *P. felix*): 107, holotype male, Mexico, Tamaulipas, San Fernando; 108, allotype female, Mexico, Tamaulipas, San Fernando.

Fig. 109.—*P. felix*: Female type, epigynum.

Fig. 110.—*P. gratus* (= *P. felix*): allotype epigynum.

Remarks.—The figures given by the Cambridges for the epigynum of *P. felix* are quite different. The figure in volume I is poor and does not resemble anything we have seen from Mexico or Central America. The figure of the epigynum in volume II resembles that of specimens from Turrialba and of the allotype of *Pirata gratus* Gertsch and Davis from Veracruz. If the type of *P. felix* was not available one could not be certain of the relationship of these two populations to *P. felix*.

Pirata browni Gertsch and Davis
Figs. 113-114

Pirata browni Gertsch and Davis, 1940, Amer. Mus. Nov., 1059:9, fig. 18 (female, Rio Gualolejo, Tamaulipas, Mexico, A.M.N.H., examined).

Remarks.—The holotype is a well pigmented female with a distinct submarginal light band on the carapace and annulae on the legs (Fig. 113) and a carapace that measures 1.7 mm long, 1.2 mm wide, putting it in the size range of *P. turrialbicus* and *P. felix*. It differs from these two in pattern and from the former in shape of the epigynum (Fig. 114). The epigynum is also different from that of *P. felix* in that the lobes do not project as far posteriorly; it has some resemblance to that of *P. sedentarius* and *P. suwaneus*.

We have found no specimens which we could place in this species, but believe the species should stand pending additional collecting in the Tamaulipas and Veracruz areas.

Pirata turrialbicus, n. sp.
Figs. 115-121

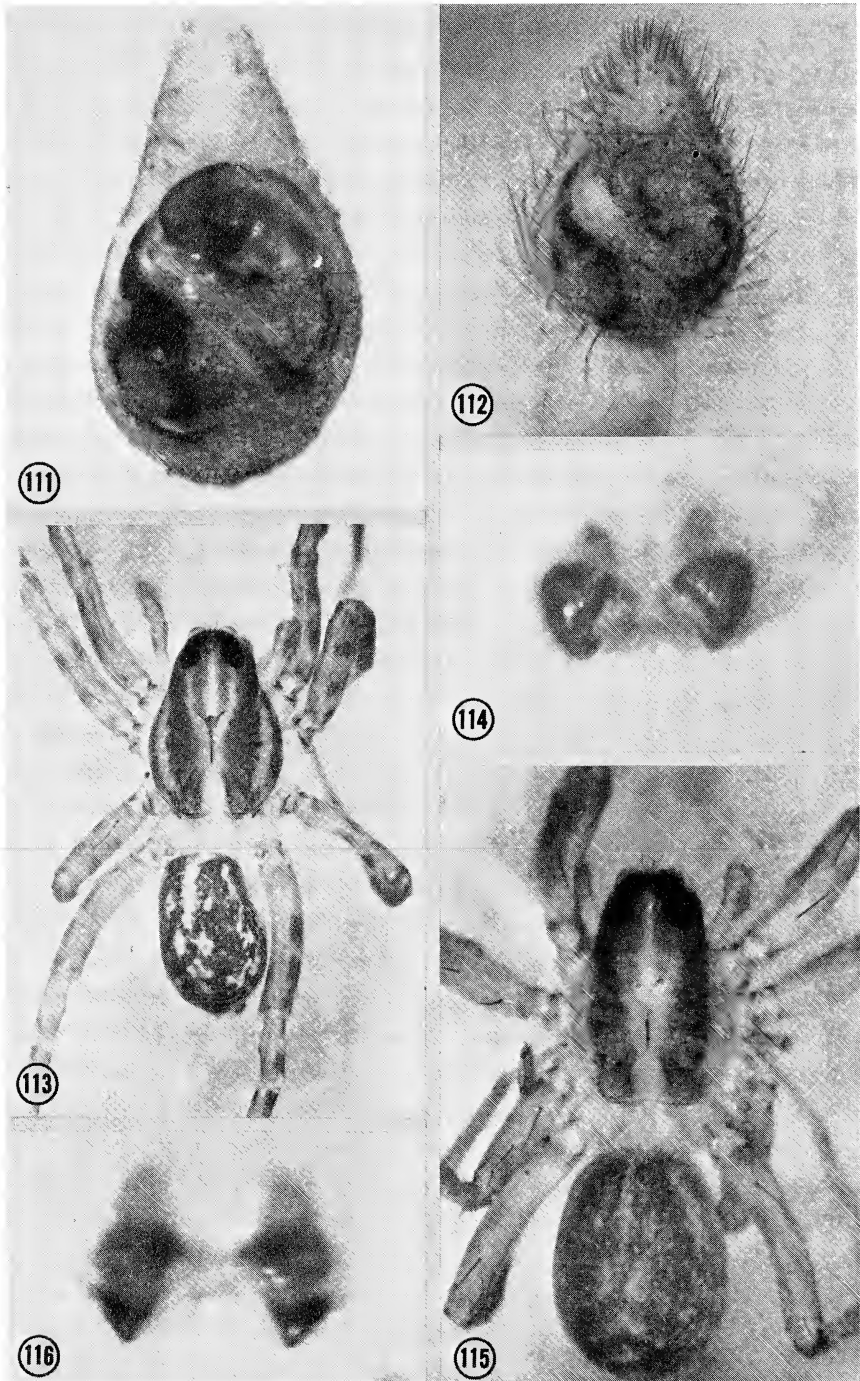
Holotype.—Female, from Turrialba, Costa Rica, 25 July-15 Aug. 1965, A. M. Chickering (M.C.Z.).

Allotype.—Male, with same data (M.C.Z.).

Diagnosis.—This species is close to *P. felix* Cambridge, *P. suwaneus* Gertsch, *P. veracruzae* Gertsch and Davis, and *P. browni* Gertsch and Davis. The latter two are known only from the holotypes and may be examples of *P. felix*. *P. suwaneus* differs from *P. felix* and *P. turrialbicus* in having a submarginal light band on carapace and resembles *P. browni* and *P. veracruzae* in this respect. The epigyna of these species are very similar, but the range of variation in the series, while small, is sufficient to cause confusion. A typical *P. turrialbicus* epigynum from Costa Rica is different from a typical *P. suwaneus* epigynum from Florida or a *P. felix* epigynum from Mexico. In the former the lobes are rather sharply pointed posteriorly, heavily pigmented at the tips and straight or concave laterally while in the latter two the lobes are not as pointed, are not pigmented at the tips, and are convex laterally (Figs. 109, 116, 118, 132).

P. browni resembles *P. suwaneus* from Florida in pattern, but the lobes of the epigynum do not possess the posterior projections of the others.

The median apophysis (Figs. 129-130, 133) of *P. suwaneus* is quite different from that of *P. felix*, *P. turrialbicus*, and *P. veracruzae* in that the distal and proximal teeth are about the same size, while in the others the distal is larger than the proximal. The palpi of the "other" three are very similar (Figs. 111-112, 120, 123-124).



Figs. 111-112.—*P. gratus* (= *P. felix*): 111, paratype, palp, Mexico, Tamaulipas, San Fernando; 112, holotype, palp, Mexico, Tamaulipas, San Fernando.

Figs. 113-114.—*P. browni*: 113, holotype female, Mexico, Tamaulipas, Rio Gualolejo; 114, holotype, epigynum.

Figs. 115-116.—*P. turrialbicus*, n. sp.: 115, female, Cuba, Soledad; 116, epigynum, Cuba, Soledad.

Description of holotype.—Total length 3.0 mm. Carapace 1.55 mm long, 1.17 mm wide with the usual tuning-fork pattern. Basic color pattern amber, carapace with a wide marginal light band. Sternum immaculate, venter faintly dusky medially. Anterior eye row narrower than the posterior median row, slightly procurved, anterior median eyes slightly closer to anterior lateral eyes than to each other, diameter of anterior median eyes almost twice that of anterior lateral eyes; clypeus equal to diameter of anterior median eyes. Lower margin of chelicerae with three teeth, median the largest.

Legs 4123, very faintly annulate. Tibia I with long overlapping ventrolateral spines, three prolateral, two retrolateral. Metatarsus I with three pairs of long spines.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.52	0.30	0.37		0.47	1.66
Leg I	1.20	0.52	0.97	0.97	0.45	4.11
Leg II	1.10	0.50	0.80	0.82	0.45	3.67
Leg III	1.00	0.45	0.72	0.95	0.47	3.59
Leg IV	1.45	0.53	1.23	1.48	0.57	5.26

Description of allotype.—Total length 1.5 mm. Carapace 0.78 mm long, 0.58 mm wide with the usual tuning-fork pattern. Color and pattern similar to holotype. Anterior eye row narrower than the posterior median row, procurved, anterior median eyes about half again as large as anterior lateral eyes, anterior eyes almost evenly spaced. Clypeus equal to the diameter of an anterior median eye (Fig. 121). Lower margin of the furrow of chelicerae with three teeth, the median largest, the lateral quite small.

Legs 4123, faintly annulate. Tibia I with five overlapping ventral spines, three prolateral and two retrolateral, and one small prolateral apical spine. Metatarsus I with three pairs of long spines.

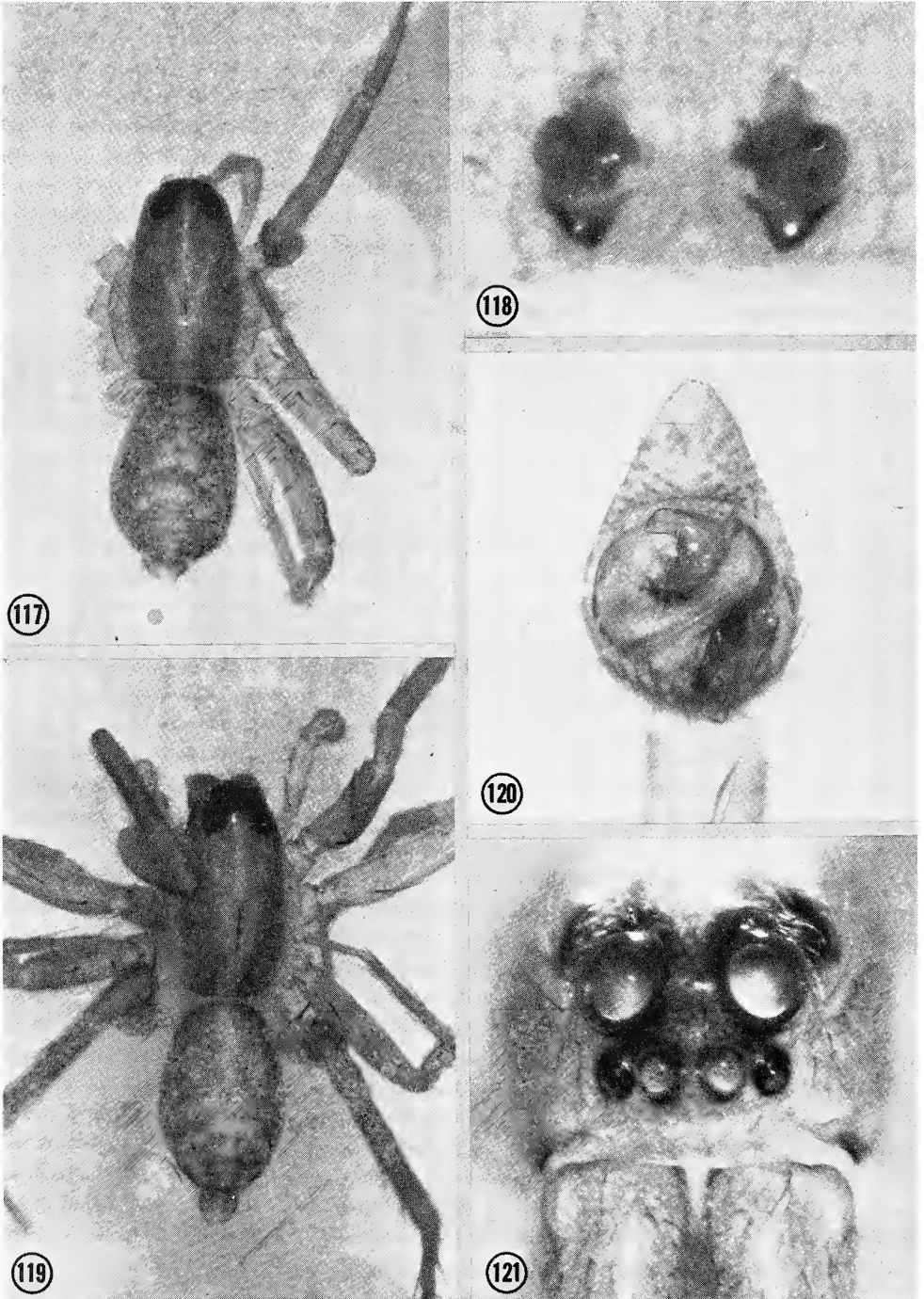
	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.55	0.25	0.30		0.52	1.62
Leg I	1.22	0.52	1.05	1.10	0.55	4.44
Leg II	1.12	0.50	0.87	1.00	0.52	4.01
Leg III	1.13	0.47	0.77	1.00	0.47	3.84
Leg IV	1.50	0.53	1.52	1.55	0.60	5.70

Distribution.—Cuba, Costa Rica, Panama.

Specimens examined.—*Cuba*: Soledad, 31-VII-33, N. A. Weler, 1 female (M.C.Z.); Soledad, 1-11 Aug 1934, P. J. Darlington, 6 females (M.C.Z.); Soledad, Apr. 36, Darlington, male, female (M.C.Z.). *Costa Rica*: Turrialba, 23 July-15 Aug. 1965, A. M. Chickering, several hundred males and females (M.C.Z.); Turrialba I.I.C.A., 8 Mar. 67, W. Peck, 3 females (Exline); 1 Mar. 67, W. Peck, male, female (Exline); San Jose, Ciudad Universitaria, CEV 72, 4 females (U.C.R. 103). *Panama*: Boquete, Aug. 1-8, 1950, A.M.C., female (M.C.Z.); Chanquinola, July 65, J. P. Harrison, 3 females (Exline); Canal Zone, Forest Preserve, XII-24-57, A.M.C., 2 males (M.C.Z.); Canal Zone, Summit Gardens, May 64, A.M.C., male, female (M.C.Z.), XII-20-57, A.M.C., 5 females (M.C.Z.), July 26, 1954, A.M.C., female (M.C.Z.), Aug. 17, 1954, A.M.C., 2 males, female (M.C.Z.); Canal Zone, 3 miles N. Pedro Miguel, Aug. 23, 1954, 2 females (M.C.Z.); El Valle, July 36, A.M.C., 4 females (M.C.Z.); Canal Zone, Aug. 28, 1950, A.M.C., 5 females (M.C.Z.); Canal Zone, Ft. Clayton, Jan. 31, 58, A.M.C., female (M.C.Z.); Canal Zone, Gatun, Feb. 58, A.M.C., 2 males, 8 females (M.C.Z.).

Life history.—*P. turrialbicus* adults probably occur throughout the year. Gaps in the records are probably a reflection of collecting activities rather than an indication of seasonal occurrence. We have a male from Cuba in April and females in April, July and

August, and egg sacs in July and August; from Panama males in February, May, August and December, females in January, February, May, July, August and December, egg sacs in February and August.



Figs. 117-121.—*P. turrialbicus*, n. sp., Costa Rica, Turrialba: 117, holotype female; 118, holotype, epigynum; 119, allotype male; 120, allotype, palp; 121, allotype, eyes.

Ecology.—The only information available comes from labels in vials: "Pasture-Berlese;" "night-open lawn-pond margin;" "under trash, cleared forest;" "banana grove."

Variations.—This small species is characterized by a wide marginal light area on carapace and faint annulae on the legs. Light specimens lack annulae and heavily pigmented specimens look like they have a submarginal band and distinct annulae on the legs. In a vial containing several hundred males and females from Turrialba lightly pigmented specimens are yellowish in color with a wide marginal light area and faint annulae on their legs. Heavily pigmented specimens have distinct annulae and pigment invading the marginal light area; these are similar to the type of *P. felix*. In this same vial one female with the marking of *P. felix* stood out because of its size: carapace 2.0 mm long by 1.5 mm wide, while typical *P. turrialbicus* measure 1.7 mm long by 1.2 mm wide. The epigynum of this specimen also resembles *P. turrialbicus*, the lobes being a little farther apart than in smaller specimens. This female is described separately below. We believe it may possibly represent a new species, but we prefer not to name it until it is verified by additional representatives including a male.

There is some variation in size. Males usually have a carapace length of less than 1.5 mm (range 1.3-1.6) and females less than 1.7 mm (range 1.4-2.0). There is also some variation in the appearance of the genitalia. The typical epigynum has a black tip on the lobes and appears to be concave in front of the tip; frequently this is true of one lobe, but not the other, sometimes depending upon the orientation of the specimen with reference to the optical path. In such cases the epigynum is very similar to that of *P. suwaneus*. The distal tooth or ramus of the median apophysis also appears to vary slightly in the length and shape, approaching *P. suwaneus* in bluntness on one extreme and *P. felix* in size and shape on the other.

Description of large female.—From Turrialba, 25 July-15 August. General body color dusky amber. Total length 5.0 mm. Some segments of legs faintly annulate. Carapace 2.0 mm long, 1.5 mm wide, with a wide marginal light area, medial edges of which are almost straight. The tuning-fork pattern is incomplete, the handle missing in front of the cervical groove. Dorsum with the usual hastate mark over the heart and several triangular shaped light areas on the midline posterior to the hastate pattern. Sides of abdomen with irregular blotches. Sternum, venter and coxae without markings.

Dorsal ocular quadrangle wider than long (0.67×0.50). Anterior eye row very slightly procurved, narrower than the posterior median row, anterior eyes evenly spaced; anterior median eyes larger than the anterior laterals. Height of clypeus slightly less than the diameter of an anterior median eye. Both tibiae I with three prolateral and two retrolateral long, overlapping ventral spines. Both tibiae II with three prolateral and two retrolateral spines ventrally, the latter long, overlapping, the prolateral about half as long as the retrolaterals. The distal prolateral spine is subapical. Legs 4123.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.67	0.37	0.45		0.67	2.16
Leg I	1.50	0.70	1.25	1.25	0.70	5.40
Leg II	1.45	0.67	1.10	1.17	0.67	5.06
Leg III	1.42	0.60	1.00	1.25	0.70	4.97
Leg IV	1.80	0.75	1.60	1.92	0.85	6.92

Pirata veracruzae Gertsch and Davis

Figs. 122-124

Pirata veracruzae Gertsch and Davis, 1940, Amer. Mus. Nov., 1059:8-9, fig. 23 (male, Potrero, Vera Cruz, Mexico, A.M.N.H., examined).

Remarks.—The holotype is a dark specimen with a carapace pigmented somewhat like *P. montanus* (Fig. 122). However, a submarginal light band is faintly visible and in this respect it does not resemble *P. felix*, although photographs of the palp resemble that of *P. felix*. At the time the holotype was examined it was noted that the palpus resembled that of *P. sedentarius* (Figs. 123-124).

The carapace of the holotype measures 1.8 mm long, 1.3 mm wide, and the eyes are typical for *Pirata*, i.e., the anterior eye row is narrower than the posterior median row and slightly procurved; the anterior median eyes are larger than the laterals.

We have found no other specimens which we could classify as this species, but neither have we been able to place it with certainty as one of the described species. In view of the small amount of collecting done in the Veracruz area we believe it best to let this species stand.

Pirata suwaneus Gertsch

Figs. 125-133

Pirata suwaneus Gertsch, 1940, Florida Entomol., 23(2):20-21, figs. 1-2 (male, female, Port Mayaca, Florida, A.M.N.H., examined); Barnes, 1953, Ecol. Monogr., 23:315-337, figs. 1-17; Barnes, 1953a, Amer. Mus. Nov., 1632:1-21, figs. 1-19.

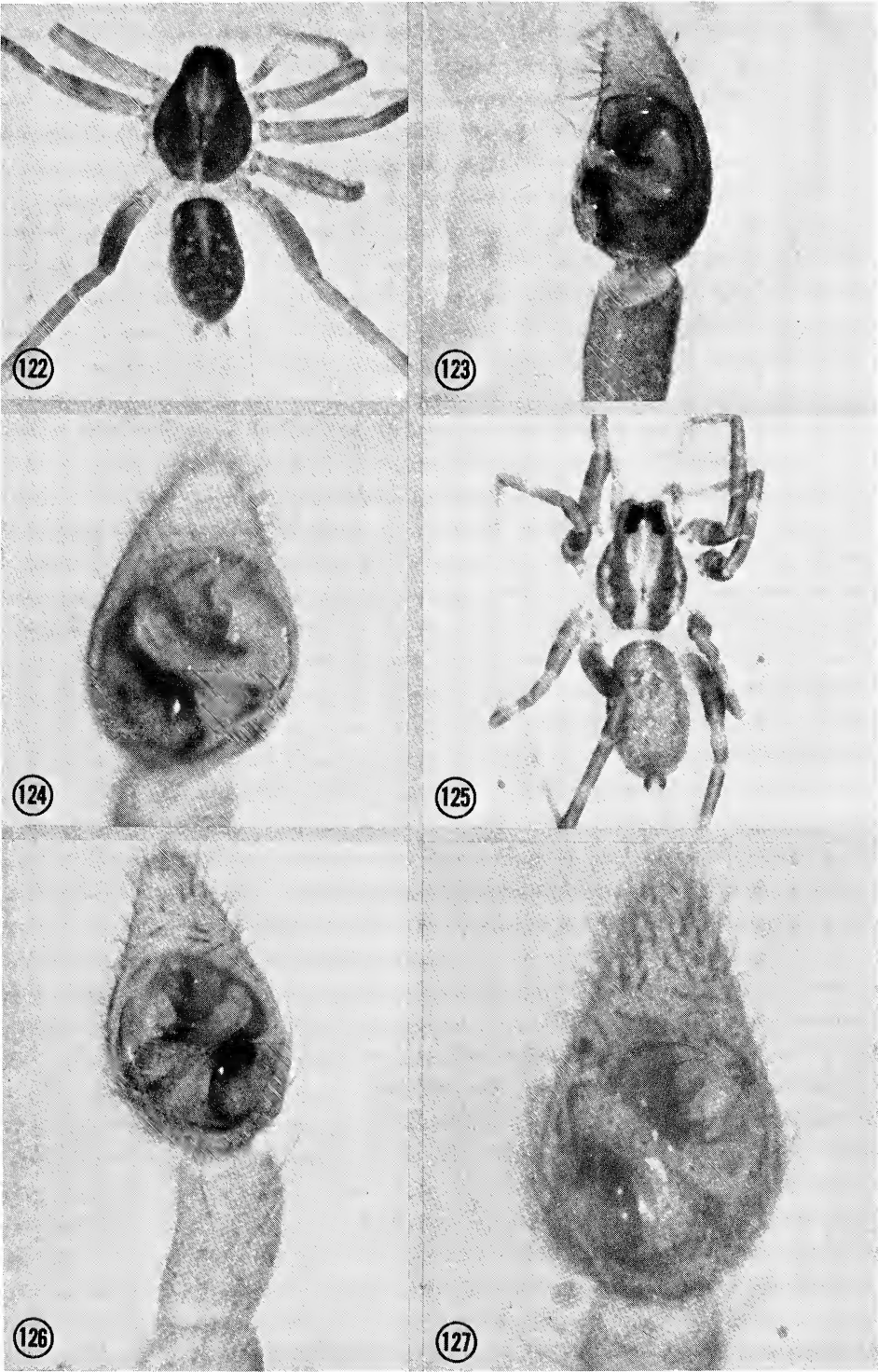
Observations on types.—Both sexes have a submarginal light band on the carapace, but the marginal pigment is not well developed, especially in the male (Figs. 128, 131). The carapace of the male holotype is 1.70 mm long, 1.07 mm wide. The anterior eye row is narrower than the median row, procurved; the anterior median eyes are twice as large as the laterals and closer to each other than to the laterals. The median apophysis of the palpus is small and chelate (Fig. 129).

The carapace of the allotype is 1.87 mm long, 1.30 mm wide. The eye arrangement is similar to that of the male. The epigynum has conical shaped structures projecting posteriorly beyond the epigastric furrow (Fig. 132).

Description of male.—From Palm Beach County, Florida, Canal Point, U. S. Sugar Corp., VIII-31-70, pitfall. Carapace 1.65 mm long, 1.22 mm wide, with a submarginal light band and the usual tuning-fork pattern. Dorsum heavily pigmented, with a light hastate mark over the heart. Sternum, coxae, labium and endites light amber colored without markings; venter similarly colored, but with pigment along the mid-line about one-third the width of the venter.

Anterior eye row distinctly procurved, distinctly narrower than the median row; anterior median eyes twice the size of the laterals, closer to the laterals than to each other. Clypeus height equal to the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with three teeth, the middle tooth the largest and closer to the lateral than to the median tooth.

Legs 4123, banded. Tibia I with seven ventral and lateral spines. The four ventral spines are long, overlapping the spines distal to them; one spine is apical in position. Tibia



Figs. 122-124.—*P. veracruzae*: 122, holotype male, Mexico, Potrero; 123-124, palp.
Figs. 125-127.—*P. suwaneus*: 125, Male, British West Indies, Crooked Island, Sept. 58; 126, palp, British West Indies, Crooked Island, Sept. 58; 127, Palp, Florida, Palm Beach Co.

II with seven ventral and lateral spines; the proximal ventroretrolateral spine overlaps the spine distal to it; the proximal ventroprolateral spine is reduced to not much more than a bristle. One spine is apical in position.

A male from the same collection is smaller than the above. Its carapace measured 1.40 mm long, 1.02 mm wide.

Description of female.—With same data. Carapace 1.67 mm long, 1.12 mm wide, with a submarginal light band and tuning-fork pattern as in the male. Dorsum with paired white spots; ventral surface yellow, immaculate except for light pigment in center of venter. Eye arrangement and toothings of chelicerae similar to male.

Legs 4123, banded. Tibia I with five ventral and lateral spines, none apical in position. Tibia II with six ventral and two lateral spines.

Variations.—There is some variation in size in this species but they are all small spiders. Male carapaces vary in length from 1.4 mm to 1.8 mm and female carapaces from 1.55 mm to 1.8 mm.

Distribution.—*P. suwaneus* probably is limited in its distribution to the southeastern United States and the West Indies. It ranges from North Carolina westward to Louisiana and Arkansas and southward throughout Florida and into the British West Indies. It does not appear to occur as far north as Tennessee; it has not been found in northwestern Arkansas where much collecting has been done, nor in Missouri.

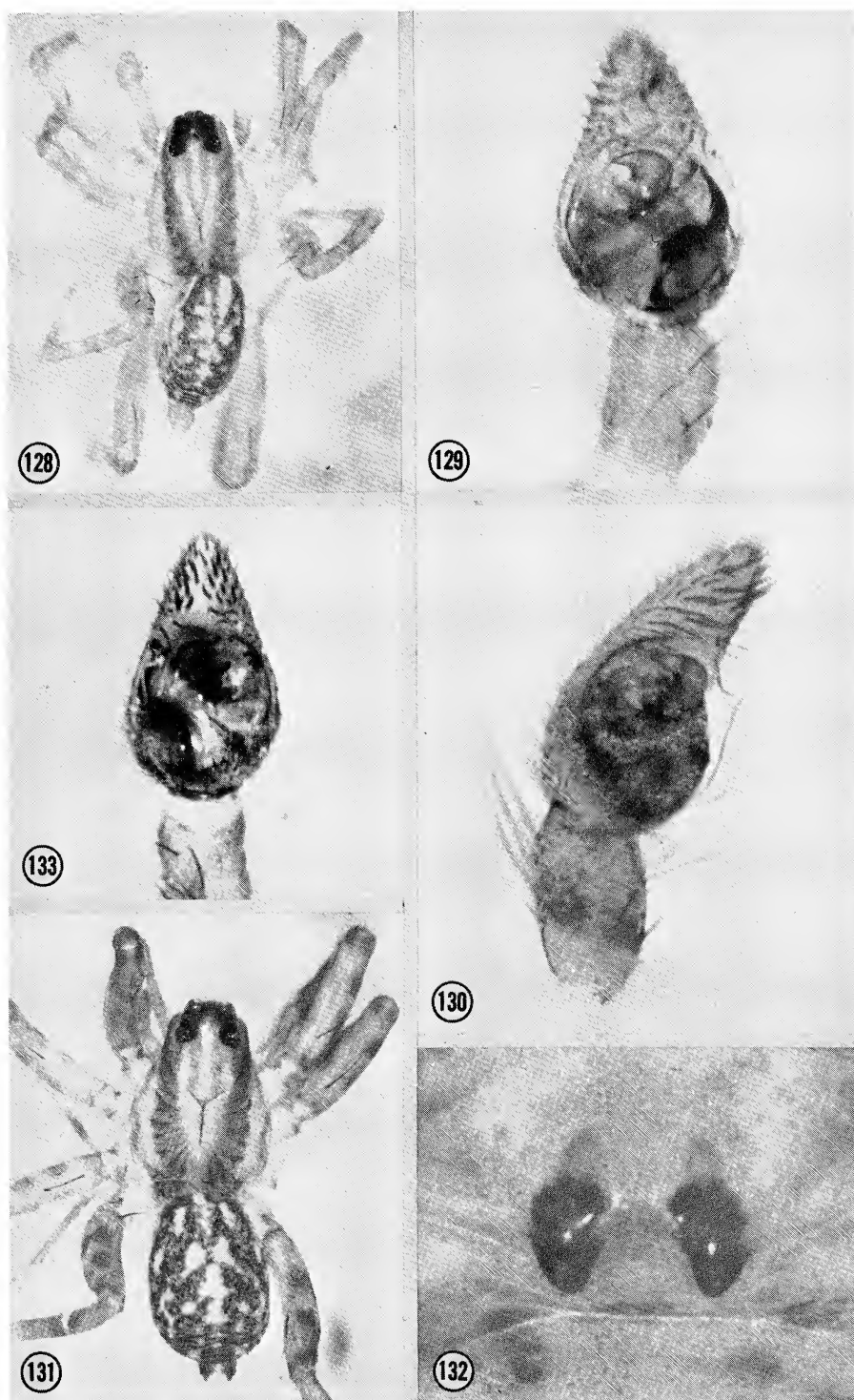
Specimens examined.—*British West Indies*: Crooked Island: Major Cay Settlement, Sept 58, A. W. Scott, Jr., male (M.C.Z.), SE of Gordon's Bluff, Sept. 58, A. W. Scott, Jr., female (M.C.Z.). *United States*: *Alabama*: Mobile County; *Arkansas*: Bradley, Conway Counties; *Florida*: Alachua, Bay, Brevard, Charlotte, Collier, Columbia, Dade, Highlands, Jefferson, Lake, Lee, Leon, Levy, Martin, Orange, Palm Beach, Putnam, Sarasota, St. Johns, Taylor Counties; *Louisiana*: St. Mary Parish; *Mississippi*: Camp Shelby; *North Carolina*: Carteret, Durham, Franklin, Orange Counties.

Life history.—In Florida adult females have been collected in every month of the year and adult males in every month from January through July. Egg sacs have been collected in all months except March, May, June and December.

Almost all records from north of Florida are from June, July and August. We have seen one male collected in Louisiana in April and one in Arkansas in September; two females in North Carolina in September and one female with egg sac in North Carolina in November. The only other egg sac from north of Florida is one collected in North Carolina in August. The male and female from the West Indies were collected in September.

Ecology.—In Florida *P. suwaneus* has been collected in a variety of wet situations: in pine flatwoods, pond margins, edge of lake, canal bank, Panama City beach, in low hammocks, cypress swamp bayheads. In Arkansas it was taken in pitfall traps in cotton fields and pastures. In North Carolina it was collected in pitfall traps in a variety of situations. Barnes (1953) demonstrated a definite habitat distribution for *P. suwaneus* in non-forest maritime communities at Beaufort, North Carolina, using pitfall traps. Barnes (1953a) listed this species as the most abundant *Pirata* in the coastal area of North Carolina.

Remarks.—The high proportion of specimens in the various collections that came from pitfall traps probably results from the small size of this species. It is easily overlooked during daylight hours and although the headlight facilitates locating them at night one might pass them by as immatures.



Figs. 128-133.—*P. suwaneus*: 128, holotype male, Florida, Port Mayaca; 129-130, holotype, palp; 131, allotype female, Florida, Port Mayaca; 132, allotype, epigynum; 133, palp, Florida, Palm Beach Co.

We have found *P. suwaneus* identified as *P. sedentarius*, *P. minutus*, *P. aspirans* and *P. insularis*, but one should be able to distinguish this small species by comparing the genitalia with the illustrations (Figs. 126-127, 129-130, 132-133). The median apophysis of *P. suwaneus* is chelate and the epigynum is characterized by the conical shaped lobes that project posteriorly beyond the epigastric furrow.

THE *PIRATICUS* GROUP

Pirata piraticus (Clerck)

Figs. 134-139

Araneus piraticus Clerck, 1757, Svenska Spindlar, p. 102, pl. 5, tab. 4 (female, type not examined).

Aranea piratica Olivier, 1789, Encycl. Method., 4:218.

Pirata prodigiosa Keyserling, 1876, Verh. Zool.-Bot., Gesell. Wien, 26:669, pl. 2, fig. 2 (Bonnet, 1945, gives date 1877; Chamberlin, 1908, lists pl. 8, fig. 44; Petrunkevitch, 1911, lists pl. 2, fig. 44); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:313.

Lycosa febriculosa Becker, 1881, Ann. Soc. Entomol. Belg., p. 45, pl. 2, figs. 2, 2a (female, New Orleans, Louisiana).

Pirata febriculosa, Chamberlin, 1908, idem, p. 311-313, pl. 22, figs. 1-2.

Pirata piratica (Clerck) var. *utahensis* Chamberlin, 1908, idem, p. 313 (male, Utah).

Pirata arenicola Emerton, 1909, Trans. Connecticut Acad. Arts. and Sci., 14:208-209, pl. 6, figs. 9-9c (female, not the male, Ipswich, Massachusetts; type examined).

Pirata sylvestris Emerton, 1909, Trans. Connecticut Acad. Arts. and Sci., 14:209, pl. 6, figs. 8b, 8c (female, not the male, see remarks).

Pirata piratica, Kaston, 1938, Canadian Entomol., 70:16, fig. 1; Kaston, 1948, Bull. Connecticut Geol. and Nat. Hist. Survey, 70:309, pl. 50, fig. 1003, pl. 51, fig. 1010.

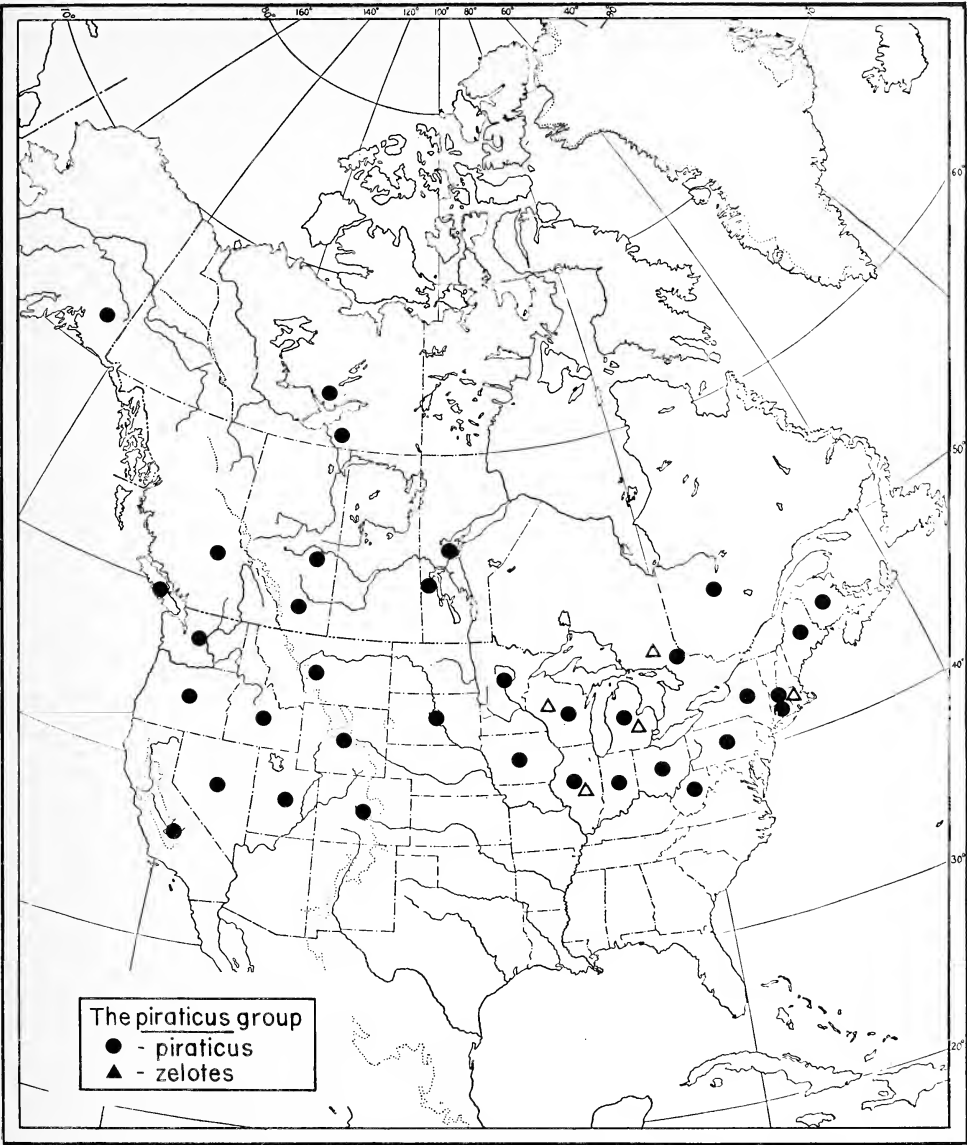
Description of male.—From the E. S. George Reserve, Livingston Co., Michigan, VII-3-1951, HKW 1448. Carapace 2.8 mm long, 2.1 mm wide with a wide marginal light area and distinct tuning-fork mark (Fig. 134). Edge of carapace with a narrow band of short white hair-like structures. Dorsum with a distinct hastate mark, three pairs of spots covered with short white hairs and distinct lateral stripes of white hairs. Sternum yellow, coxae, labium, endites and venter a little darker in color, immaculate.

Anterior eye row slightly narrower than the posterior median row, slightly procurved, anterior median eyes about twice the size of the laterals, closer to laterals than to each other. Height of clypeus about three-fourths the diameter of an anterior median eye. Lower margin of furrow of chelicerae with three, almost evenly spaced teeth which are almost equal in size.

Legs 4123, unbanded. Tibia I with three pairs of ventral spines, the distal pair apical. The proximal ventroprolateral spine on tibia II is much reduced.

Description of female.—With same data as male. Carapace 3.0 mm long, 2.3 mm wide. Pattern similar to male except white markings from short hairs or scales are more conspicuous (Fig. 135). Legs unbanded, venter dusky. Eye arrangement similar to male. Lower margin of furrow of chelicerae with three teeth, evenly spaced, equal in size.

Legs 4132, unbanded. Tibia I with two pairs of long ventral spines. Tibia II with two pairs of ventral spines; the prolateral ones much reduced in size.



Distribution.—Europe and, roughly speaking, north of the 35th parallel in North America.

Specimens examined.—Canada: *Alberta*: Altasbasca Delta, Vermillion Lakes nr Banff, Edmonton, George Lake, McMurray; *British Columbia*: Field, Ft. St. James, Vancouver Island; *Manitoba*: Cedar Lake, Kettle Rapids, the Pas; *New Brunswick*: St. Andrews; *Northwest Territory*: Ft. Resolution, Great Slave Lake; *Ontario*: Algoma, Carleton, Cochrane, Hastings, Kenora, Lennox and Addington, Nipissing, Prince Edward, Thunder, York County or District, L. Nimissire, New Sarum, Mac Bay L.N.P.S., Mere Bleu, Long Point, Wilcox Lake, Garret Island, Holst Pt., Fround Lake, MacLerian, Ft. Severn, St. Joseph's Island, Ompah; *Quebec*: Gatineau, Lac St. Jean-Quest Counties; *Saskatchewan*: Besnard Lake, Emma Lake, Indian Head, Lady Lake, Moose Mtn. Creek; *Yukon Territory*: Whitehorse. United States: *Alaska*: Kodiak, Haines, Homer, Matunuska, Rudyerd

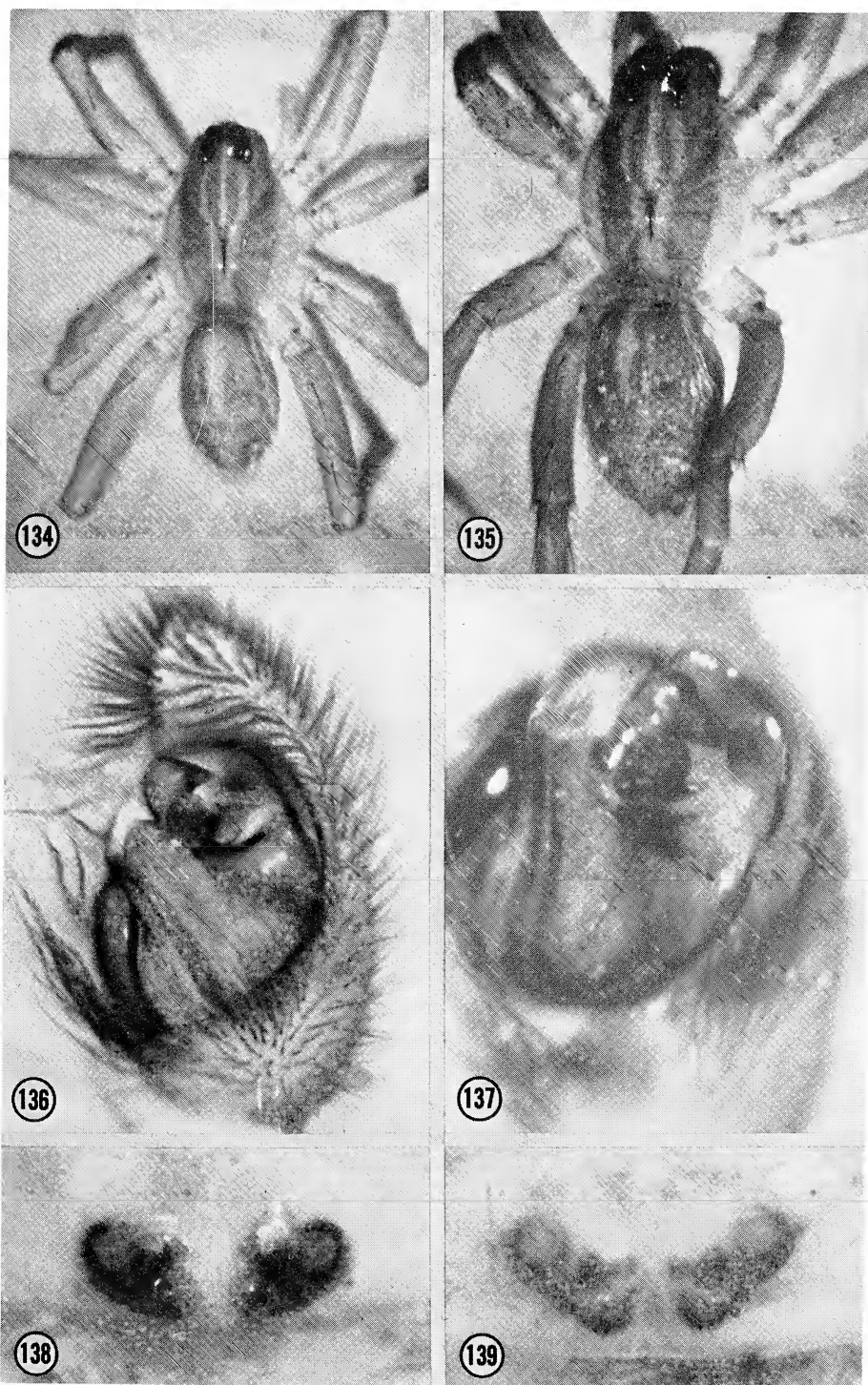
Bay Area; *California*: Alameda, Del Norte, Humboldt, Inyo, Los Angeles, Orange, Riverside, San Diego, Siskiyou, Shasta Counties; *Colorado*: Alamosa, Lake, Mesa, Larimer, Teller Counties; *Connecticut*: New Haven County; *Idaho*: Adams, Blaine, Franklin, Idaho, Latah, Oneida, Owyhee, Payette, Shoshone, Valley, Washington Counties; *Illinois*: Elkhart and La Porte Counties; *Iowa*: Cerro Gordo County; *Maine*: Washington County, Wals; *Massachusetts*: Hampden, Middlesex, Nantucket Counties; *Michigan*: Algar, Baraga, Berrien, Calhoun, Charlevoix, Cheboygan, Clare, Clinton, Delta, Emmet, Gogebic, Kalamazoo, Livingston, Luce, Macomb, Marguette, Menominee, Midland, Missaukee, Oakland, Ogemaw, Roscommon, Schoolcraft, Tuscola Counties; *Minnesota*: Crow Wing, Freeborn, Polk, Roseau, Stearns, Wadena Counties; *Montana*: Carbon, Sanders Counties; *Nevada*: 20 mi W Elks, Wadsworth; *New York*: Columbia, Rensselaer, Schuyler, Tompkins, Wayne Counties; *Ohio*: Erie, Ottawa Counties; *Oregon*: Benton, Coos, Deschutes, Douglas, Harvey, Klamath, Lane, Linn, Multnomah, Umatilla Counties; *Pennsylvania*: Lancaster, Pike, Potter Counties; *South Dakota*: Grant County; *Utah*: Davis, Emery, Grand, Millard, Rich, Salt Lake, Utah Counties; *Washington*: Clark, Cowlitz, Grant, Jefferson, King, Lincoln, Okanogan, San Juan, Snohomish, Spokane Counties; *West Virginia*: Pocahontas County; *Wisconsin*: Dane, Dodge, Florence, Iron, Polk, Rock, Taylor, Waukesha Counties; *Wyoming*: Albany, Laramie, Platte, Teton Counties, Yellowstone National Park.

Life history.—In the United States 95 percent of the records are from May, June, July and August. We have two records of males and females from February, and several from October; none from November through January. We have records of males and females from California in March and one egg sac from March. Most records of egg sacs are from July, a few from June and August, and one from September. *P. piraticus* appears to mature about a month later in Canada; almost all of our Canadian records are from June, July, August and September.

Ecology.—The information available (mostly from labels) indicates that *P. piraticus* is usually found near water; in swamps, marshes, or on the shores of lakes, ponds and streams. One record by B. Malkin, June 21, 1951, from Hot Springs at the SE end of Harvey Lake has four males, four females, three immatures from "upper layer running on surface of hot water."

Wallace collected this species on numerous occasions on the E. S. George Reserve, Livingston Co., Michigan, from marsh, swamps, woods pond, and bog. *P. insularis* and *P. piraticus* were frequently taken together. On one occasion, collecting a marsh by separating plants along muskrat trails and by shining eyes, *P. aspirans*, *P. cantralli*, *P. minutus*, *P. piraticus* and *P. zelotes* were collected in the same part of the marsh.

Remarks.—We have found this species identified as follows: *P. aspirans*, *P. febriculosus*, *P. insularis*, *P. prodigiosus*, *P. sylvestris*, *P. utahensis*, *P. wacondana*. Chamberlin and Ivie (1944) listed two females from Georgia. The one from Marshallville, June-24-1910; R. V. Chamberlin, is *P. sedentarius*; the one from Gainesville we have not examined. Becker (1881) described *Lycosa febriculosa* from New Orleans, Oklahoma; various authors have since synonymized his species with *P. piraticus*. Although we have not seen the type we doubt that Becker's specimen was *P. piraticus* for two reasons: (1) we have examined no other *P. piraticus* from within hundreds of miles of New Orleans; (2) Becker illustrated the anterior row of eyes as wider than the posterior median row and this is not true of any *Pirata* that we have examined. Banks (1892) reported *P. piratica* as uncommon around Ithaca, New York; in 1895 he reported it as occurring on Long Island under leaves in swamps.



Figs. 134-139.—*P. piraticus*: 134, male, Michigan, Livingston Co., E. S. George Reserve; 135, female, Michigan, Livingston Co., E. S. George Reserve; 136, palp, Michigan, Livingston Co., E. S. George Reserve; 137, palp, Michigan, Gull Lake; 138, epigynum, Massachusetts, Ipswich (type of *P. arenicola*); 139, epigynum, Ontario, St. Josephs.

Emerton did not give a locality for *P. sylvestris*. We received a vial from the M.C.Z. labeled *Pirata sylvestris* Em., Lynn Woods, June 11, 1905, J. H. Emerton, coll., which contained a female *P. piratica* and a male *P. insularis*, evidently the same specimens he illustrated.

The number of ventral spines of tibia I and II have been used as a generic character. The following data from five male and 22 female *P. piraticus* indicates that this may be a consistent character in males, but not in females:

Apical-Tibia I		Apical-Tibia II		Number Cases	
Right	Left	Right	Left	Male	Female
0	0	0	1	0	4
0	0	1	0	0	2
0	0	1	1	0	10
0	0	0	0	0	3
1	1	0	1	0	2
1	0	1	1	0	1
2	2	2	2	5	0

***Pirata zelotes*, n. sp.**

Figs. 140-142, 145

Holotype.—Male, Michigan, Livingston Co., E. S. George Reserve, M-28 VII-15-54, H.K.W. 1789H (M.C.Z.).

Allotype.—Female, with same data (M.C.Z.).

Etymology.—The name of this species comes from the Greek word “zelotes” meaning “emulator,” selected because of its close resemblance to *P. piraticus*.

Diagnosis.—*Pirata zelotes* is most closely related to *P. piraticus* and in Michigan occurs in the same marsh or swamp with it, but they can be distinguished from each other by their patterns on the carapace and the structure of the genitalia. *P. zelotes* has a sub-marginal light band on the carapace, *P. piraticus* a wide marginal light band. The tip of the median apophysis is pointed in *P. piraticus* with the anterior border straight while in *P. zelotes* the tip is not so sharply pointed (Fig. 136) and the anterior border is rounded or convex (Fig. 142). The differences in epigyna can best be determined by studying the illustrations (Figs. 138-139, 145).

Description of holotype.—Carapace 2.8 mm long, 1.9 mm wide, with a distinct sub-marginal light band and the usual tuning-fork pattern. Dorsum of abdomen with light colored hastate mark and white scales forming four pairs of spots and lateral stripes. Ventral surface of body and coxae immaculate, sternum lighter in color than the rest, venter a little darker.

Anterior eye row narrower than median row, somewhat procurved. Anterior median eyes twice as large as laterals; closer to laterals than to each other. Clypeus height equals the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with three equally spaced teeth which are almost equal in size; the middle tooth is the largest, the median the smallest.

The palpus is similar in structure to that of *P. piraticus*, but differs in that the median apophysis is not as sharply pointed as it is in *P. piraticus*. Legs 4123, femora with faint annulae.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	1.02	0.48	0.63		0.83	2.96
Leg I	2.13	0.97	1.62	2.10	0.90	7.72
Leg II	1.90	0.83	1.38	1.78	0.80	6.69
Leg III	1.75	0.75	1.20	1.75	0.75	6.20
Leg IV	2.45	0.93	2.05	2.80	1.05	9.28

Description of female allotype.—Carapace 3.3 mm long, 2.3 mm wide, with a distinct submarginal light band and the usual tuning-fork pattern. Dorsum with light hastate mark and white scales forming indistinct paired spots. Venter and epigastric region unmarked, lighter than the sides of the abdomen. Sternum with heavily sclerotized rim and lightly pigmented each side of the light colored center. Labium much darker than endites.

Eye arrangement similar to that of the male. Lower margin of the furrow of the left chelicera with three, almost equal teeth; right chelicera with four teeth.

Legs 4123, femora with faint annulae.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	1.13	0.58	0.67		0.85	3.23
Leg I	2.30	1.07	1.67	1.80	0.80	7.64
Leg II	2.13	1.00	1.43	1.68	0.78	7.02
Leg III	2.05	0.95	1.38	1.75	0.80	6.93
Leg IV	2.75	1.10	2.30	3.10	1.10	10.35

Variation.—The number of cheliceral teeth varies from three on the left to four on the right in the allotype. This species is fairly uniform in size throughout its range. One female from Ontario has a very flat and wide carapace (2.50 mm long, 2.25 mm wide). We have also seen this characteristic in *P. piraticus* from the western United States.

Distribution.—We have examined specimens from Michigan, Illinois, Massachusetts and Ontario, Canada.

Specimens examined.—Canada: *Ontario*: Cordova Mines nr. Marmora, 12 July 62, J. H. Redner, female (A.M.N.H.). United States: *Illinois*: Lake Co., Volo, bog, June 8, 1941, D. C. Lowrie, female (D.C.L.); Volo bog, V-16-36, D. C. Lowrie, 1 male, 7 penultimate males, 3 penultimate females (D.C.L.); *Massachusetts*: Middlesex Co., Lexington, V-29-26, P.J.D., 1 male, 2 females (M.C.Z.); *Michigan*: Kalamazoo Co., Gull Lake Biol. Sta., 14-22 July 65, T. F. Hlavac, male (H.K.W.); Livingston Co., E. S. George Reserve, E-17, VI-26-51, H. K.W. 1430, female (H.K.W.); M-28, VII-14-54, H.K.W. 1788A, 1 female, 1 imm female (H.K.W.); M-28, VII-15-54, H.K.W. 1789 H, 4 males, 4 females (holotype and allotype, A.M.N.H.; paratypes, H.K.W.); M-28, VII-19-54, H.K.W. 1796 H, 2 females, 1 imm (H.K.W.); *Wisconsin*: Dane Co., Madison, 29 May 1957, Dunn's Marsh, J.L.K., female (H.K.W.).

Life history.—Very little is known about this species. One male was collected in Massachusetts on May 29, 1926, by P.J.D. (Darlington) and identified as *P. insularis* by Mr. Emerton or Miss Bryant, and as *P. piratica* by Miss Exline in 1965. D. C. Lowrie collected one male, seven penultimate males, and three penultimate females in Volo, Illinois, on May 16, 1936. They were in a vial with *P. piraticus*. Wallace collected the E. S. George Reserve in Michigan during June, July and August in 1951, 1954 and 1957. He got one female on June 26, 1951. All the other males and females and one sac were collected in July. It would appear to be a species that matures in mid-summer.

Ecology.—All of the specimens we have examined were collected in swamps or marshes. Wallace collected *P. zelotes*, *P. piraticus*, *P. insularis* and *P. aspirans* from Stone-

Ring Marsh on the E. S. George Reserve in a standing-water zone. This zone had clumps of willow (*Salix amygdaloides*), pure stands of spike rush (*Eleocharis obtusa*) and pure stands of *Dulichium arundinacium*. There were also present several species of *Carex*, *Scirpus*, and *Sagittaria latifolia*. Wallace also collected *P. minutus* along with *P. zelotes* and *P. piraticus* from the edge of a swamp on the Reserve.

Remarks.—The data on this and several other species of *Pirata* leads one to think that the surface has not been scratched very deeply in the collecting of members of the genus. Thorough collecting will probably extend the ranges of many of our species and turn up additional new ones.

THE *SEDENTARIUS* GROUP

Pirata sedentarius Montgomery

Figs. 143-144, 146-162

Pirata sedentarius Montgomery, 1904, Proc. Acad. Nat. Sci. Philadelphia, 56:312-313, pl. 19, figs. 28-29 (male, female, Austin, Texas; A.M.N.H., examined).

Pirata wacondana Scheffer, 1904, Entomol. News, 15(8):260, pl. 17, fig. 7 (female, Waconda, Kansas; M.C.Z., examined).

Pirata californica Banks, 1904, Proc. California Acad. Sci., 3(13):356, pl. 39, fig. 13 (female, Mariposa Co., California; type is said to have been destroyed in San Francisco earthquake).

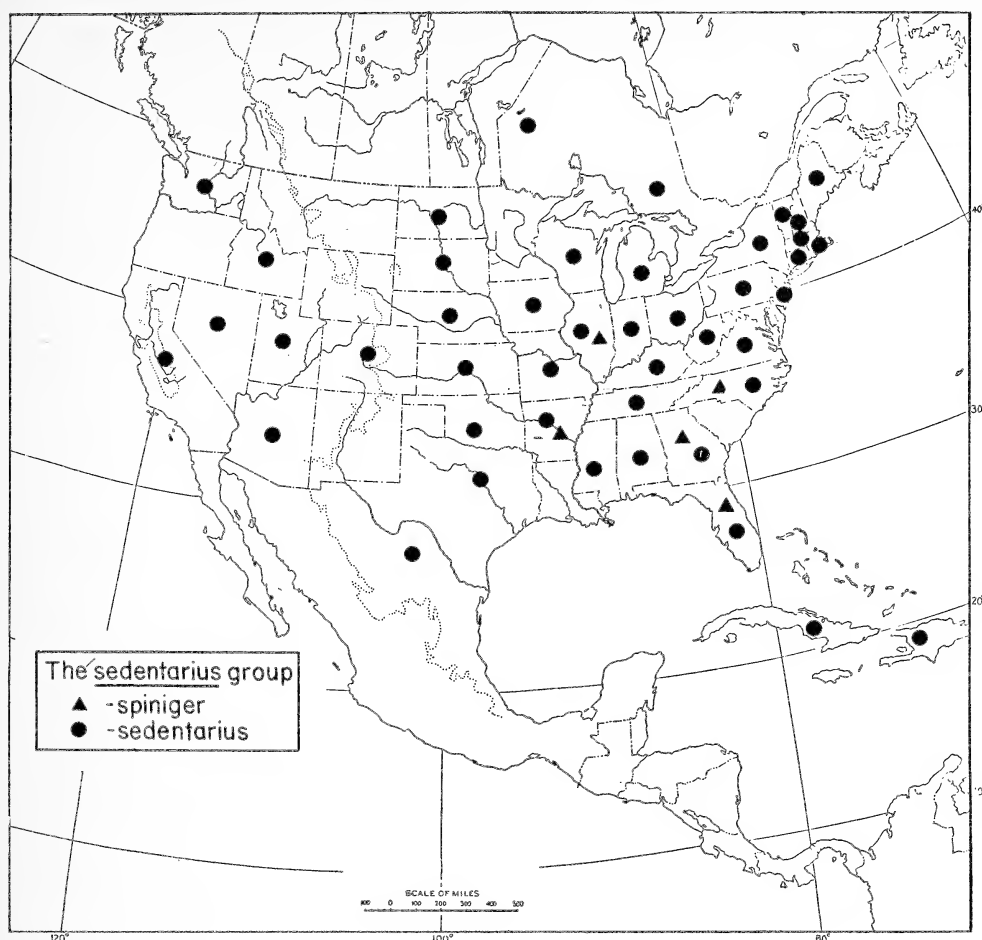
Pirata maculatus Emerton, 1909, Trans. Connecticut Acad. Arts and Sci., 14:209, pl. 6, figs. 10, 10a, 10b (female, Moosehead Lake, Maine; M.C.Z., examined); Kaston, 1938, Canadian Entomol., 70:16, fig. 3; Kaston, 1948, Bull. Connecticut Geol. and Nat. Hist. Survey, 70:311-312, pl. 49 (990-991), pl. 50 (fig. 1007), pl. 51 (fig. 1013). NEW SYNONYMY.

Remarks on types.—The “types” of *P. sedentarius* are in a vial bearing A.M.N.H. red holotype and allotype labels. Their carapace measurements are: male, 3.2 mm long, 2.4 mm wide; female, 3.0 mm long, 2.2 mm wide.

A female labeled *Pirata wacondana* Scheffer, Waconda, Kans., 23 Aug., N. Banks coll., received from M.C.Z., has a carapace 3.0 mm long by 2.1 mm wide. The ventral spines on tibia I are 2:2:0:0; on metatarsus I are 2:2:2. The anterior eye row is straight, about as wide as the median row; the anterior eyes are about evenly spaced, the anterior medians are about twice the size of the laterals. The posterior median eyes are separated by about one diameter; the clypeus height equals a diameter of an anterior median eye (Fig. 144).

A female labeled “*Pirata maculata* Em. Type. Me. Moosehead Lake, Aug. 7, 1904, J. H. Emerton. ‘Deer Is.’ Dried up, Relaced 1958” was received from the M.C.Z. This specimen matches Emerton’s figures. The carapace is 3.0 mm long, 2.2 mm wide. The anterior eye row is narrower than the median row, is almost straight; the anterior median eyes are larger than the laterals and closer to them than to each other.

Description of male.—From Austin, Texas, July 7, 1946, Don L. Frizzell. Carapace 2.80 mm long, 2.00 mm wide. The body and legs are very light amber color and the legs are conspicuously hirsute. Dorsally there is almost no pigment pattern and ventrally the animal is immaculate.



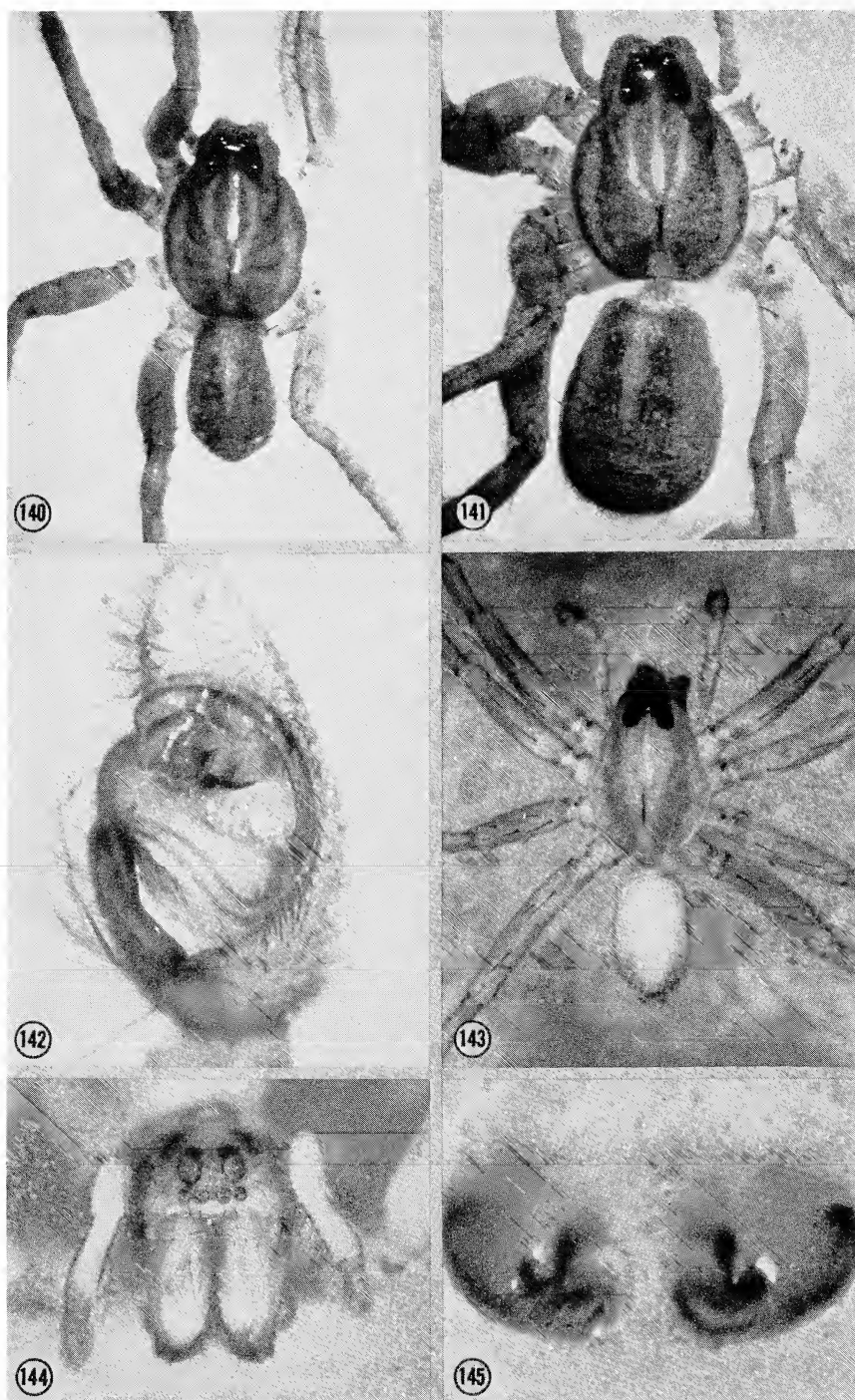
Anterior eye row narrower than the posterior median row, slightly procurved, the anterior median eyes about half again as large as the anterior laterals; these four eyes about evenly spaced. Clypeus height slightly greater than the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with three unequal teeth, the middle tooth the largest and closer to the lateral than to the median tooth.

Legs 4123, unbanded. Tibia I with four long overlapping, ventral, two lateral and one apical spines. Tibia II with four ventral, two lateral and one apical spines. The proximal ventro-prolateral spine is conspicuously reduced in size.

Description of female.—from Austin, Texas, July 7, 1946. Carapace 3.20 mm long, 2.37 mm wide, with a wide marginal light area and pigmented tuning-fork pattern. Dorsum with light hastate mark lightly bounded by scattered pigment; with four pairs of spots and the sides covered with white scales. Ventral surface immaculate.

Anterior eye row and clypeus similar to the male, lower margin of the furrow of the chelicerae armed as in the male.

Legs 4123, unbanded. Tibia I with two pairs of long, ventral, overlapping spines. Tibia II with four ventral, one prolateral, and one apical spines. The ventral prolateral spines are reduced to bristles.



Figs. 140-142.—*P. zelotes*, n. sp.: 140, holotype male, Michigan, E. S. George Reserve; 141, allotype female, Michigan, E. S. George Reserve; 142, palp, Illinois, Volo, V-16-36.

Fig. 143.—*P. sedentarius*: Male, Cuba, Trinidad Mts., Buenos Aires, 9 May 36.

Fig. 144.—*P. wacondana*: Type female ($\approx P. sedentarius$), eyes, Kansas, Wacondana.

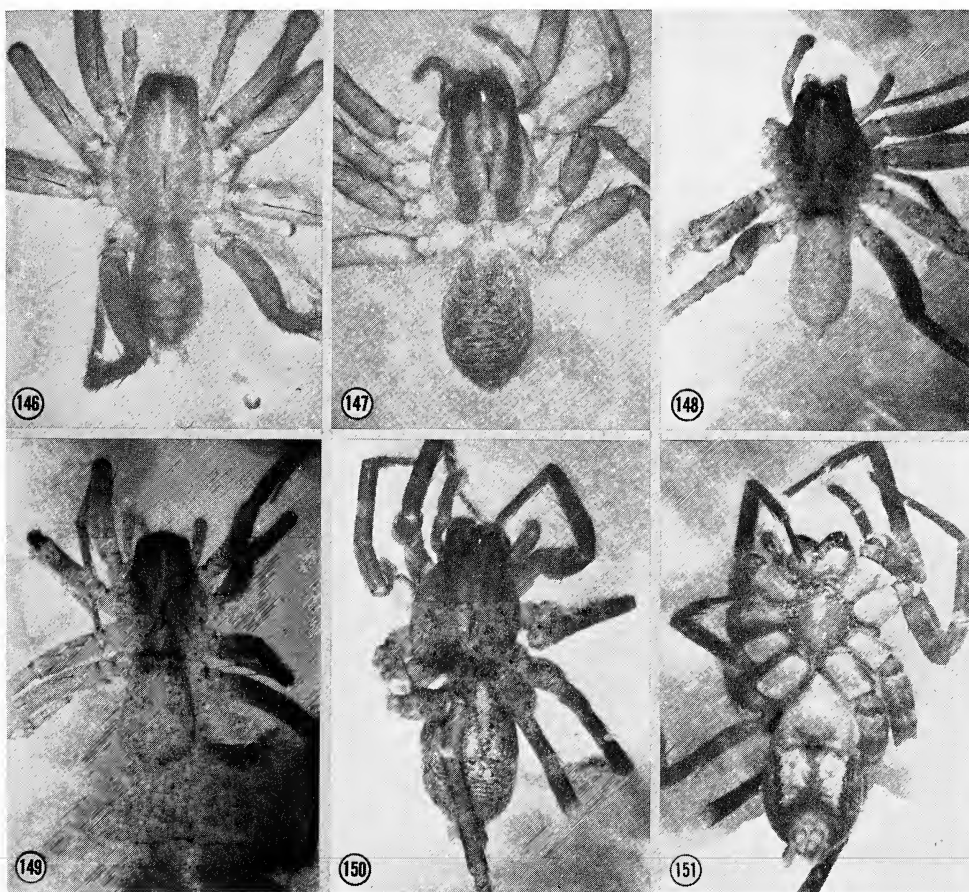
Fig. 145.—*P. zelotes*, n. sp.: Epigynum, Illinois, Lake Co., V-8-41.

Variation.—*Pirata sedentarius* usually has a pattern which, although difficult to put into words, is characteristic for that species; it probably will take a lot of study before one can recognize it from that of other *Pirata*. In Texas this species sometimes has no pattern as a result of lack of pigment.

There is also considerable variation in size but this appears to be a local rather than regional phenomenon. The smallest male measured, from Arkansas, had a carapace 1.7 mm long, the largest from Texas, 3.2 mm long. Females from Arkansas varied in carapace length from 1.7 mm to 3.2 mm. The largest from Mexico, measured 3.3 mm. Females from Virginia ranged from 2.5 to 2.9 mm in carapace length.

Distribution.—Southern Canada, United States, Mexico, Cuba, Haiti.

Specimens examined.—Canada: *Manitoba*: Daphin, June 17, 1963, T.B.K., female (ROM); *Ontario*: York Co., Elmhurst Beach N9 W7, July 15, 1931, T.K., female (ROM); Aug. 15, 1931, T.K., female, egg sac (ROM 526); Toronto, June 4, 1934, E.O., female, egg sac (ROM 4529); *Saskatchewan*: nr. Val Marie, Bank Frenchman River, June 14, 1969, D.J.B., female (D.J.B.); Moose Mtn. Creek, 3W OXBOW, 4 July 1968, D.J.B., 3



Figs. 146-149.—*P. sedentarius*: 146, male, Texas, Austin, 30 July 68, B. Vogel; 147, female, Michigan, Kalamazoo Co., 11-18 Aug 65; 148, Type male, Texas, Austin; 149, Type female, Texas, Austin.

Fig. 150.—*P. maculatus*: Type female (= *P. sedentarius*), Maine, Moosehead Lake.

Fig. 151.—*P. maculatus*: Type female, ventral view.

females, egg sacs (D.J.B.). *Cuba*: Trinidad Mts., Buenos Aires, 9 May 36, 2500-3500 ft., P. J. Darlington, male (M.C.Z.); Soledad, June 29, P. J. Darlington, female (M.C.Z.). *Haiti*: Petion, Wm. M. Mann, female (M.C.Z.); Etangha Chaux, 27 Oct. 34, P. J. Darlington, female (M.C.Z.). *Mexico*: *Coahuila*: Arroya de la Cruz, 18 Dec. 41, H.K.W. 1147, 2 females (H.K.W.); *Nuevo León*: Horsetail Falls, 31 Aug. 68, J.E.C. 347, female (J.E.C.); *Tamaulipas*: Rancho Santa Ana, 24 Dec. 41, H.K.W. 1156, 2 males, 3 females (H.K.W.); *Hidalgo*: 10 mi NE Cardonal, Grutas de Tonoltingo, 1 Aug. 47, J. Reddell, J. Fish, 3 males, 13 females, imm. (A.M.N.H.). *United States*: *Alabama*: Clarke, Lowndes, Mobile, Russell, Tuscaloosa Counties; *Arizona*: Cochise County, White Mts., Virgin Narrows; *Arkansas*: Bradley, Carroll, Conway, Craighead, Franklin, Hempstead, Madison, Perry, Washington Counties; *California*: Inyo, San Bernardino, San Diego Counties; *Colorado*: Douglas, Larimer Counties; *Connecticut*: Fairfield, Litchfield, Middlesex Counties; *Florida*: Alachua, Dade, Henry, Highlands, Lake, Levy, Liberty, Marion, Pinellas, St. Johns Counties; *Georgia*: Baker, Macon, Thomas Counties; *Idaho*: 10 mi. S. Swan Valley, 7-6-35, W.I., female (A.M.N.H.); *Illinois*: Cook, Jackson, Jo Davies, Lee, Livingston, Macoupin, Morgan, Peoria, Pope, Union Counties; *Indiana*: Turkey Run, 28 May 32, D.C.L., male, female (D.C.L.); *Iowa*: Cerro Gordo, Washington Counties; De Witt, 26 June 10, R.V.C., 3 females (A.M.N.H.); *Kansas*: Riley County *Kentucky*: Brewthitt, Edmonson, Powell Counties; *Maine*: Moosehead Lake, 7-VIII-1904, J.H.E., immatures (M.C.Z.); *Massachusetts*: Franklin, Middlesex, Nantucket Counties; *Michigan*: Genesee, Ingham, Kalamazoo Counties; *Mississippi*: Hinds County; *Missouri*: Boone, Crawford, Dent, Jefferson, Johnson, Osage, Phelps, Saint Genevieve, Saline Counties; *Nebraska*: Burwell, Cheyenne, Dawson, Hall Counties; *Nevada*: Clark County; *New Hampshire*: Francoria County; *New Jersey*: Burlington, Morris Counties; *New York*: Columbia, Delaware, Nassau, Ontario, Rensselaer, Tompkins Counties; *North Carolina*: Buncombe, Cartaret, Durham, Macon, Swain, Transylvania, Wake Counties; *North Dakota*: Divide County; *Ohio*: Erie, Wayne Counties; *Oklahoma*: Delaware, Marshall, Wayne Counties; *Oregon*: Baker County; *Pennsylvania*: Adams, Allegheny, Fayette, Potter Counties; *Rhode Island*: Washington County; *South Dakota*: Camp Judson; *Tennessee*: Roane, White Counties; *Texas*: Dallas, Hays, Hidalgo, Kerr, McClennan, Travis, Uvalde Counties; *Utah*: Cache, Grand, Millard, Salt Lake, Utah Counties; *Vermont*: Mt. Mansfield; *Virginia*: Giles, Powell, Rappahannock, Shenandoah, Smyth Counties; *Washington*: Pierce County; *West Virginia*: Ohio, Pocahontas, Summers Counties; *Wisconsin*: Eau Claire, Rock Counties.

Life history.—The data on the collection of adults appears to reflect the monthly activity of collectors rather than the life history of this species. We have recorded males and females from Mexico only in August and December. In Florida it looks like two broods a year. We have adult males and females from January through June with egg sacs in April and young in June. July, August and September are a blank. In October we have adult males and females with egg sacs.

Most of the collections in the southeastern United States are from June, July and August, but we have females from every month but November, December and February and males from February through September. We have examined egg sacs from April through August.

Maturity appears to occur a little later in the northeastern United States. We have one male from March, Males from May through August and one in November, females from May through November. We have egg cases from June through October.

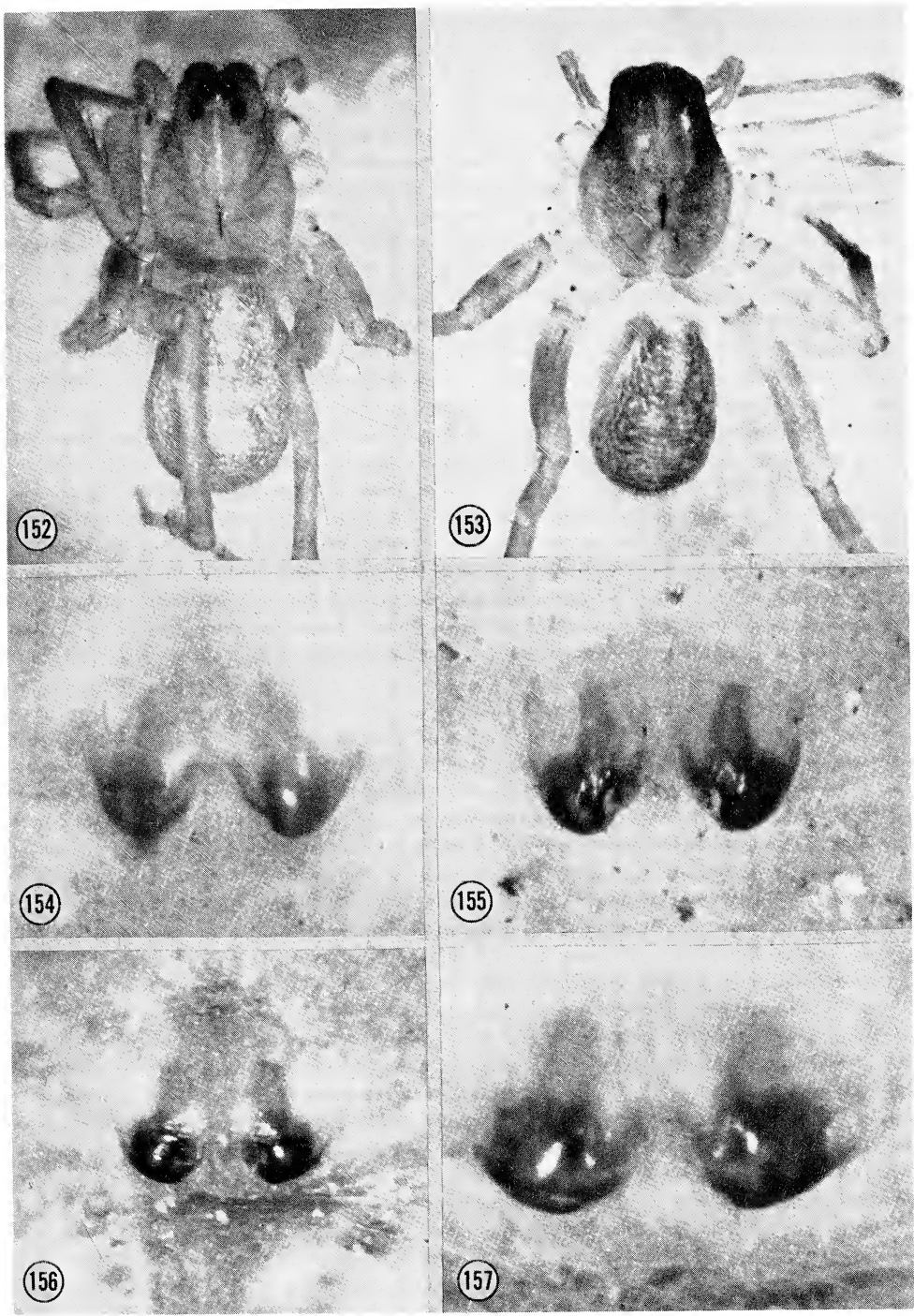


Fig. 152.—*P. wacondana*: Type female (= *P. sedentarius*).

Figs. 153-155.—*P. sedentarius*: 153, female, Hayti, Petion; 154, epigynum, Arkansas, Washington Co.; 155, type female, epigynum, Texas, Austin.

Fig. 156.—*P. maculatus*: Type female (= *P. sedentarius*), epigynum.

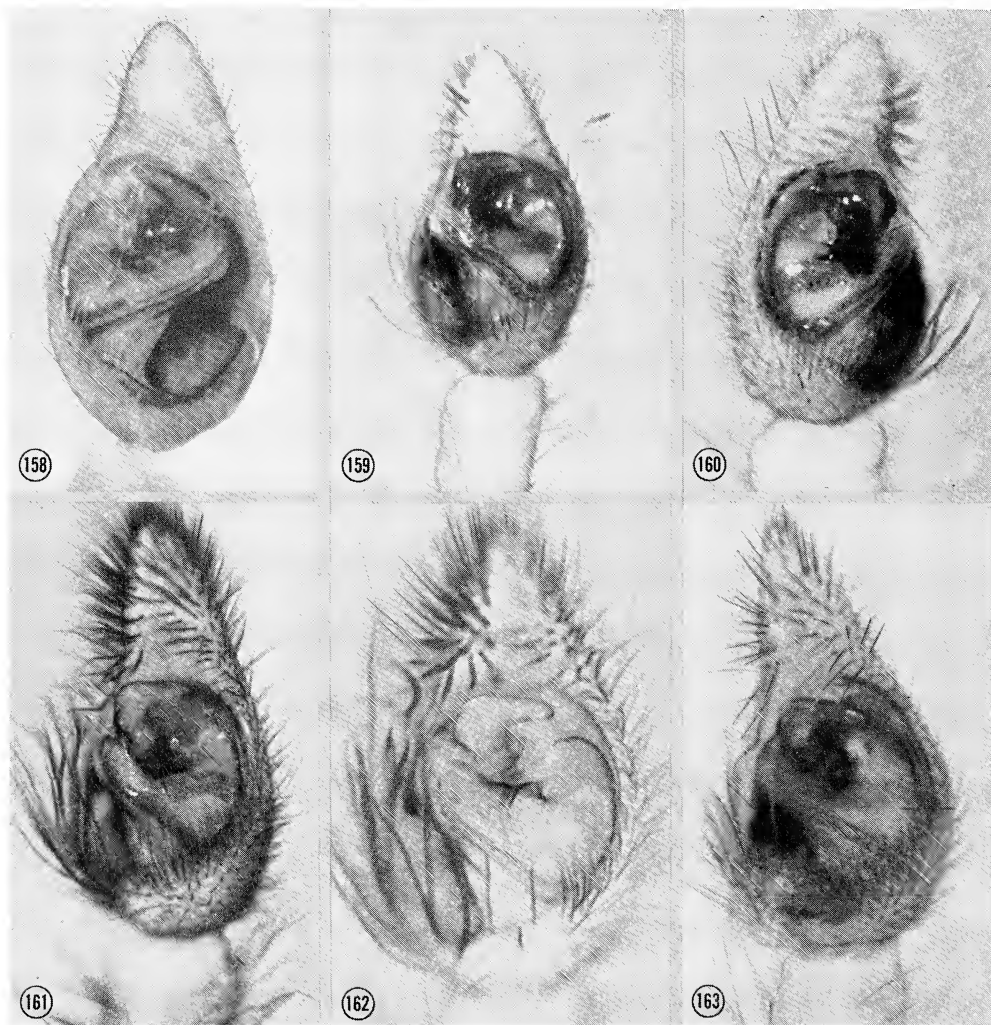
Fig. 157.—*P. wacondana*: Type female (= *P. sedentarius*), epigynum.

The data from the western United States are very similar to the southeast. Males are recorded from March through September and females from March through November and one in January. Egg cases occur from April through August.

The data from Canada are scanty. We have females with egg sacs from June, July and August, but no males.

Ecology.—*Pirata sedentarius* is collected usually in the vicinity of water. Wallace collected it in Mexico under rocks in a dry stream bed. Other collectors have also recorded it from similar situations. In Florida it is usually found in hyacinth mats, around cypress bays in flatwoods, and around ponds. It has also been recorded from *Neofiber* burrows.

In Arkansas it has been collected near a grassy lake, under rocks, near streams, and at night on Odell Mountain in an open oak-hickory woods. In Georgia it was collected on the surface film of a mossy pond; in Illinois from a rocky stream bank; from a salt marsh



Figs. 158-162.—*P. sedentarius*: 158, type male, palpus, Texas, Austin; 159, palp, Georgia, Baker Co.; 160, palpus, Cuba, Trinidad Mts.; 161, palpus, Arkansas, Washington Co.; 162, palpus, Tennessee, Kingston.

Fig. 163.—*P. spiniger*: Palpus, Florida, Alachua Co.

in Massachusetts; in the vicinity of a spring in Missouri; near a river in Nebraska; on the shore of Utah Lake.

Remarks.—The relative length of the palpal tibia has been cited as distinguishing *P. sedentarius* from *P. maculatus*, being twice as long as thick in the latter and only one and one-half times as long in the former. *P. maculatus* is usually considered to occur in the northeastern U.S. and *P. sedentarius* in the south. These two cannot be distinguished by this character in the specimens I have examined.

The palpal tibia is more than twice as long as thick in every female that I have measured from Vermont to Mexico and every male measured from Georgia, Florida, Alabama, Texas, Oklahoma and Mexico have palpal tibia at least twice as long as thick. Males from Arkansas vary in this character, most being slightly less than twice as long as thick. This condition also varies in males from Pennsylvania; in one vial I found two males with the proportions 31/19 and 40/20. Two other males from Pennsylvania had proportions of 32/19 and 35/22.

The only population we have found with palpal tibia consistently shorter than twice the thickness is from Giles Co., Virginia, where every male measured (9) had palpal tibiae less than twice as long as thick.

We have never found a male with palpal tibia as short as one and one-half times its thickness.

Preserved *P. sedentarius* that we have examined vary in coloration from lightly pigmented specimens with no pattern and unbanded legs through specimens with a typical *Pirata* pattern and banded legs to specimens with a black carapace. Also, the marginal pigment is not continuous so that the animal appears to have a wide marginal light band with flecks of pigment near the rim of the carapace.

Pirata spiniger (Simon)

Figs. 163-168

Sosilaus spiniger Simon, 1898, Histoire naturelle des Araignees, 2(2):350, fig. 340; Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:298, pl. 12, figs. 5-6; Comstock, 1912, The spider book, New York, p. 649; Hubbell and Goff, 1939, Proc. Florida Acad. Sci., 4:152.

Description of male.—From Melbourne, Florida, 1/9/55. Einem: Carapace 2.20 mm long, 1.57 mm wide, without markings. Legs and carapace from above amber in color, dorsum of abdomen light yellow, almost white in color. Ventrally there is no pattern, the sternum and venter slightly lighter in color than the legs. The muscles in the cephalothorax are faintly visible from above giving the carapace a faint striated appearance.

The anterior eye row is wider than the posterior median row, and is straight. The anterior median eyes are twice as large as the anterior laterals and the same size as the posterior laterals; and are closer to each other than to the laterals. The clypeus height equals the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with three, almost equally spaced teeth, the median tooth the largest, the other two similar in size.

Legs 4123, unbanded. Tibia I with twelve long, overlapping ventrolateral, two prolateral, and retrolateral spines. Metatarsus I with nine ventrolateral and lateral spines, the distal pair far removed from the apical position. Tibia II with 12 long overlapping,

ventrolateral, two prolateral, and two retrolateral spines. Metatarsus II with nine ventrolateral and lateral spines. Palpus very similar to that of *P. sedentarius*.

Description of female.—With same data as male. Carapace 2.25 mm long, 1.68 mm wide, immaculate. Female resembles the male in lacking pigmented pattern, in coloration, in eye arrangement, and cheliceral dentition. The epigynum appears to be identical with that of *P. sedentarius* (Fig. 168).

Legs 4123. Tibia I with 11 ventrolateral, three prolateral, one retrolateral, and one dorsal spine. The ventrolateral spines are long and overlapping. Tibia II with ten long, overlapping ventrolateral spines; and two prolateral, two retrolateral and one dorsal spine.

Variation.—*P. spiniger* does not vary much in size and usually is quite light in color with no pigment. However, freshly collected specimens may show traces of pigmentation.

C. C. Goff near Dade City, Florida, collected four adult specimens from the same *Geomys* tunnel in which all of the eyes were the same size as the anterior laterals.

Distribution.—Southeastern United States.

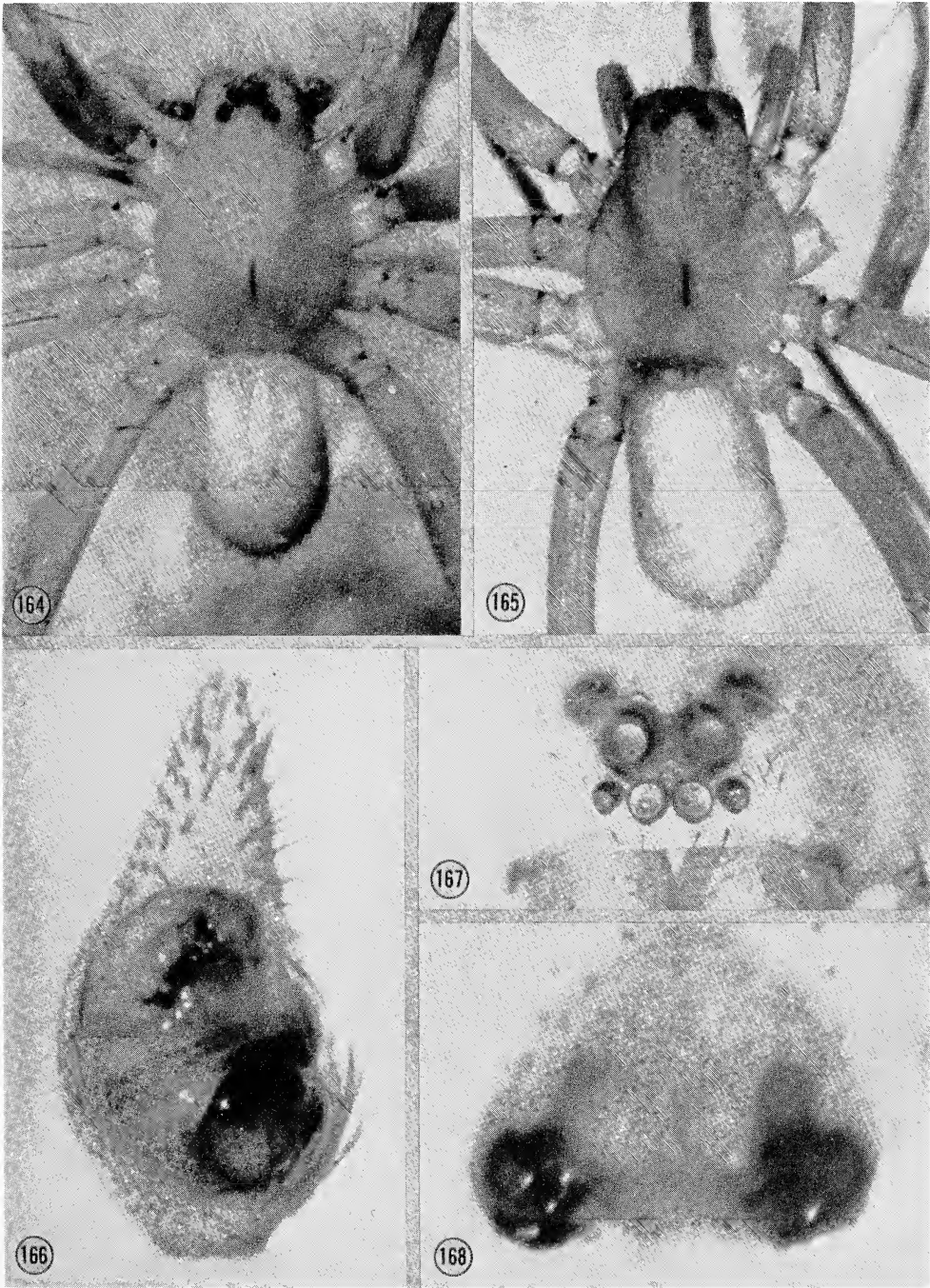
Specimens examined.—*Arkansas*: Craighead Co., Jonesboro, XI.10.66, pitfall, oak woods, Exline, female (Exline); *Florida*: Alachua, Brevard, Hillsborough, Lake, Leon, Nassau, Putnam Counties; *Illinois*: Jackson Co., S. of Carbondale, X.20.68, Union Hills, Adams, male, 2 imms. (J.A.B.); *North Carolina*: Durham Co., VII.16.63, Gate 3 Duke Forest, N. from 751, mixed pine and hardwood, pitfall, Berry, male (J.A.B.); VII.1.63, Chapel Hill Blvd. E. of county line, Russel Farm, broomsedge field, pitfall, Berry, male (J.A.B.).

Life history.—In Florida and Georgia adults of *P. spiniger* will probably be found throughout the year. Most of our records of adults in Florida are from May, June, July and August, but we have both sexes from January and females from September. From Georgia we have records of both sexes from February and April and a female with egg sac from May. All of this data reflects the activity of collectors. John Anderson at the University of Florida had a female that made an egg sac on 21 July, five days after mating. He also had young emerge from an egg sac on 8 August. Data from the other states are too meager to be meaningful.

Ecology.—*P. spiniger* was a very rare spider in collections until C. C. Goff demonstrated that it inhabits pocket gopher tunnels (*Geomys*). It had been taken once or twice in gopher turtle burrows. In recent years it has been collected in pitfalls in various types of plant associations; by sifting leaf litter in high pine turkey oak by W. M. Barrows at Gainesville, Florida, and on the University of Florida Conservation Reserve, Welaka, Florida; by Wallace in pine flatwoods by raking pine needle litter and shining the exposed areas with a head light. The pine needles were interlaced between the blades of wiregrass clumps so thickly that they formed a sort of roof an inch or two above the ground and it appeared to Wallace that this formed a dark, damp environment not unlike that of a pocket gopher tunnel. From the evidence at hand one is encouraged to think that this is a species that evolved from *P. sedentarius* in a cave environment, that the usual habitat is still cave-like, i.e., *Geomys* tunnels or tortoise borrows, but that it occasionally wanders into dark damp situations such as leaf litter, or under stones or boards.

Remarks.—On the basis of the structure of the genitalia *P. spiniger* is more closely related to *P. sedentarius* than *P. sedentarius* is to any other *Pirata* known to us. These two species are very similar in size and when pigment is present in *P. spiniger* its pattern is like that of *P. sedentarius*. The anterior eye row is wider than the posterior median row in *P. spiniger* (narrower in *P. sedentarius*) and the spining of the legs is unique, but to us this species is very closely related to *P. sedentarius*. It appears to be a species developed in

cavernicolous isolation, perhaps during periods of glaciation, where it acquired some of the modifications, i.e., reduced eyes, reduced pigment, spine and sense organ modifications, not unusual in cave-dwelling species.



Figs. 164-168.—*P. spiniger*: 164, male, Florida, Melbourne; 165, female, Florida, Melbourne; 166, palpus, Florida, Leon Co.; 167, male, eyes, Florida, Melbourne; 168, epigynum, Florida, Alachua Co.

SPECIES OF UNCERTAIN RELATIONSHIP

Pirata alachuus Gertsch and Wallace

Figs. 169-174

Pirata alachua Gertsch and Wallace, 1935, Amer. Mus. Nov., 794:9, figs. 34, 36 (types: male, female, Alachua Co., Florida, A.M.N.H., examined).

Etymology.—This species was named for the county in which the type specimens were found.

Description.—A small spider, the carapace usually less than 2.0 mm long in males and less than 2.4 mm in females, with a wide marginal light band on the carapace, otherwise resembling *P. sedentarius* in pattern, and indistinct annulae on legs. Anterior eye row slightly procurved, slightly narrower than posterior median eye row. Epigynum with posteriorly rounded lobes about one-half diameter apart. Median apophysis of palp unique, truncated anteriorly so that it has somewhat the shape of a tomahawk or hatchet. The distal (anterior) end of the median apophysis is sometimes transparent and difficult to see.

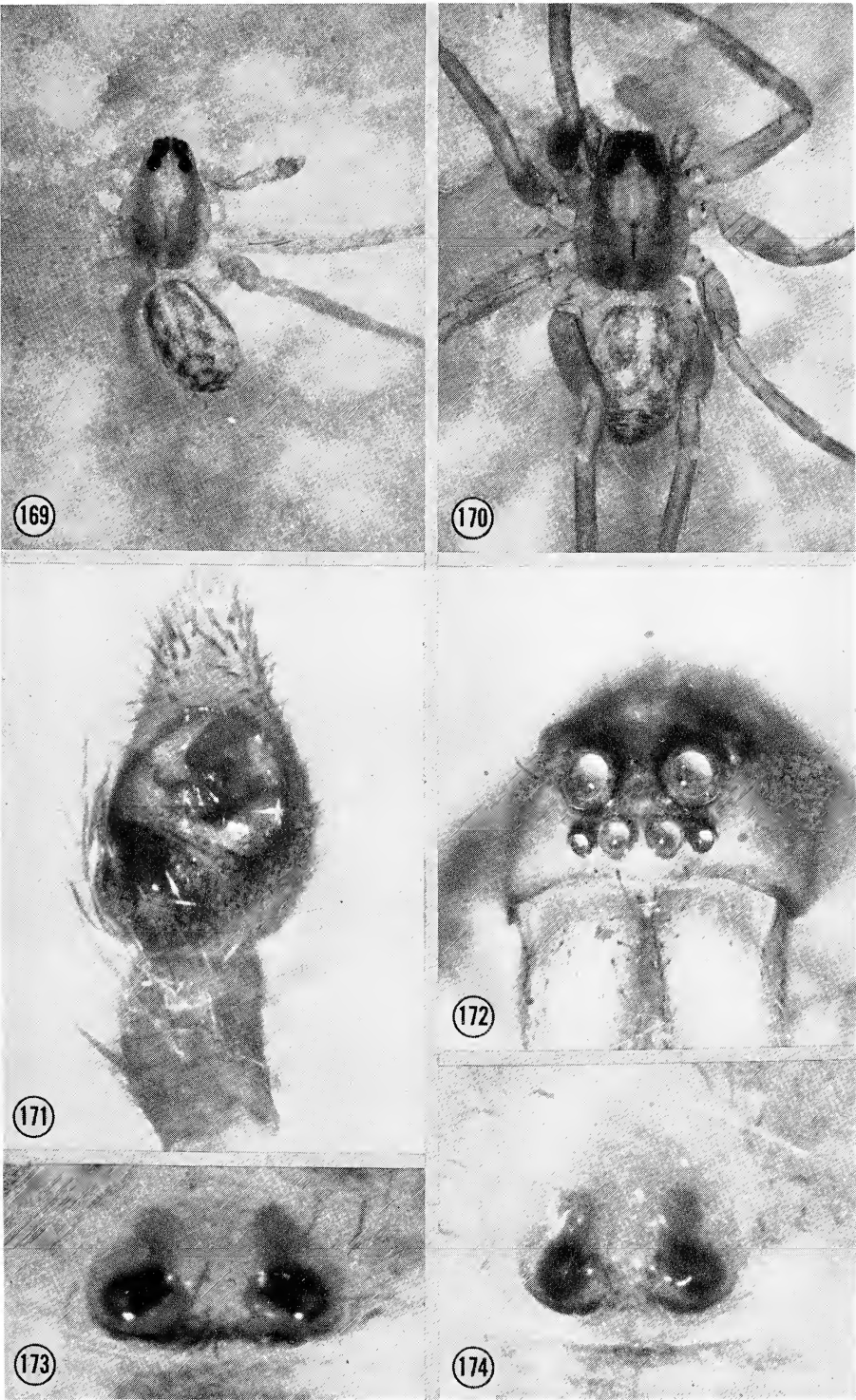
Distribution.—*Alabama*: Blount, Houston, Macon Counties; *Arkansas*: Bradley, Conway, Craighead, Hempstead, Mississippi Counties; *Florida*: Alachua, Columbia, Gadsden, Highland, Jackson, Lake, Leon, Liberty, Marion, Nassau, Orange, Pasco, Putnam, Sumter Counties; *Georgia*: Baker, Burke, Walker, Ware Counties; *Illinois*: Jackson, Pope, Union Counties; *Indiana*: La Porte County, Williamsburg; *Maryland*: Montgomery County; *Mississippi*: Wilkinson County, Camp Shelby; *Missouri*: Crawford, Johnson, Phelps, Ripley, Stoddard Counties; *North Carolina*: Durham, Lincoln Counties; *Ohio*: Warren County; *South Carolina*: Aiken County; *Virginia*: Albermarle, Nasemond, Norfolk Counties.

In addition we have examined females from New Jersey, Tennessee and Texas which resemble *P. alachuus*, but males are needed from these states to confirm them as state records. The female from New Jersey resembles *P. sedentarius* in size and appearance, but the epigynum is very similar to *P. alachuus* from Florida.

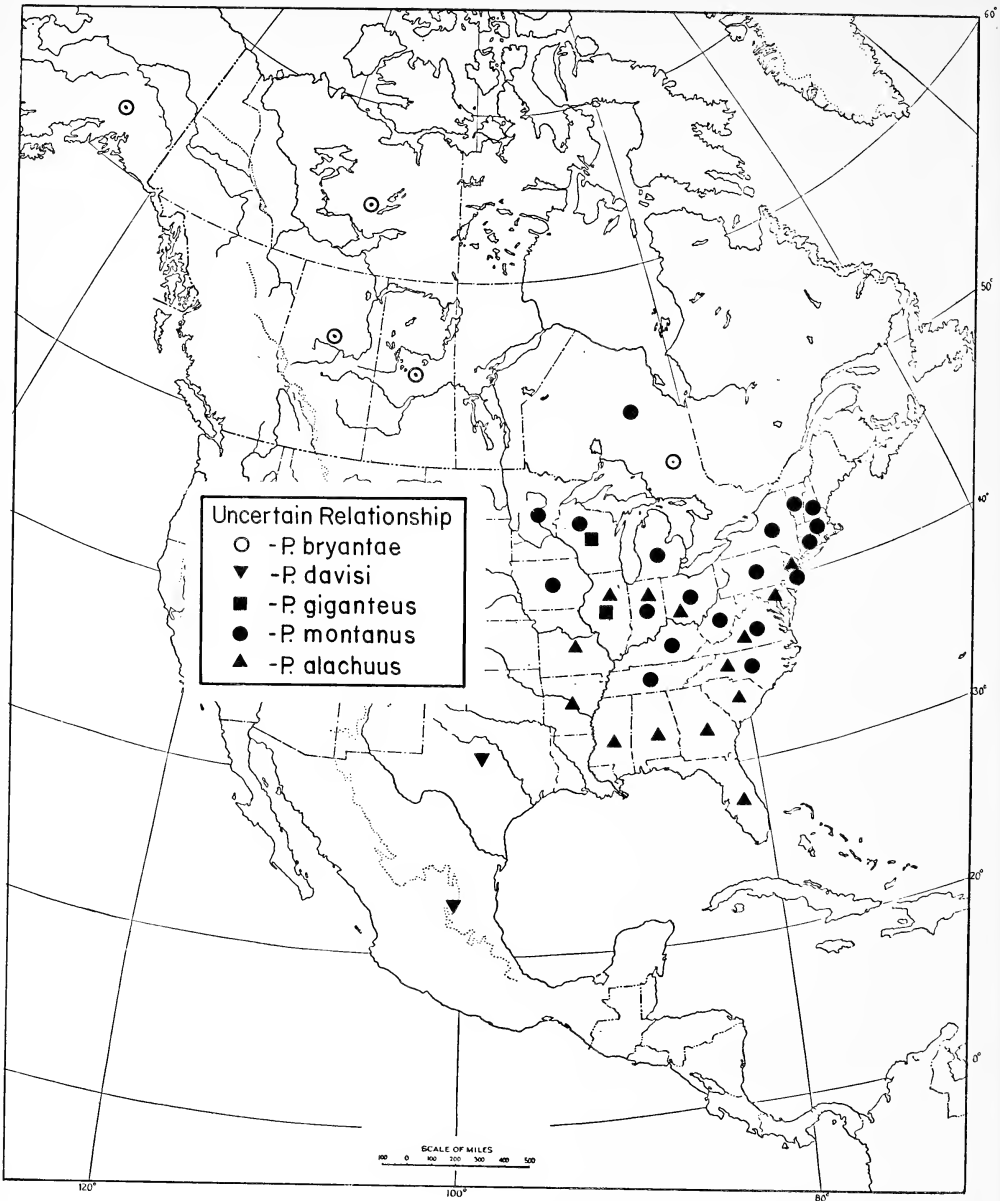
Life history.—*P. alachuus* is a summer spider; 95 percent of all specimens collected come from April, May, June and July. In the northeastern part of the U.S. males have not been taken earlier than May or later than July with 90 percent from May and June. In Florida adult males begin to appear in March with the season of maturity moving northward, gradually, with the isotherm. In the southern states males may be taken in August and we have a record of one male from Florida in December. No other adults are known from Florida during September, October, November and January. Three females have been taken in February.

Records of egg sacs.—Florida: April, May, June; United States: May through September with one record in January from the west. Egg sacs measure from 2.0 to 2.8 mm in diameter, and are slightly flattened dorsoventrally when first made, becoming round as the young hatch.

Ecology.—*P. alachuus* is not as riparious as most *Pirata*. It is not confined to the margins of ponds and streams and throughout its range may be found in leaf litter of mesic woods, in cultivated fields or sometimes in exposed areas. In Arkansas it has been taken in pitfall traps in pine-oak woods; in Missouri from traps in open woods, ground litter and along streams and ponds (H. Peck). Specimens from Highlands State Park,



Figs. 169-174.—*P. alachuus*: 169, holotype male, Florida, Alachua Co.; 170, allotype female, Florida, Alachua Co.; 171, palpus, Florida, Pasco Co.; 172, eyes, Florida, Jackson Co.; 173, epigynum, North Carolina, Durham Co.; 174, epigynum, Florida, Alachua Co.



Florida, were collected by A. R. Brady from under leaves and logs, and by sifting leaf litter. The following statements by collectors will give some idea of the variety of situations in which this species occurs. Arkansas: cotton field pitfall trap, Grassy Lake; Florida: under leaves and logs, wet area, edge of pond, pitfall under magnolia, woodyard hammock, pitfall under live oak in lawn, pitfall in hickory sweetgum hammock, berlese funnel, magnolia litter, leaf mould in dried up cypress-hardwood, leaf mould in creek floodplain, cypress bay-pine flatwoods margin, wet sandy banks of stream, black mucky lake shore; Illinois: leaf mould, woods, spring area, pitfall, wooded lowland, floodplain; Missouri: moist shady leaf mould, lake margin, trap-open woods, on face of sandstone cliff; North Carolina: bottomland pine with hardwood-pitfall; Virginia: Dismal swamp, reservoir; Maryland: swampy area.

Pirata bryantae Kurata
Figs. 175-180

Pirata bryantae Kurata, 1944, Occ. Pap. Roy. Ontario Mus. Zool., 8:3-4, pl. 2, figs. 1-4 (female, Favourable Lake, Ontario, R.O.M.Z. 7073, examined).

Diagnosis.—*Pirata bryantae* is a small, dark spider that looks more like a dark *Arctosa* than a *Pirata*. The carapace is dark in both sexes and lacks the tuning-fork pattern. The epigynum (Fig. 180) also resembles that of some *Arctosa*, but the palpus (Fig. 177) has a median apophysis that is somewhat like those of *P. minutus* or *P. sedentarius*.

Description of holotype.—The holotype, a female, has a carapace 2.25 mm long and 1.55 mm wide. It is now dark and faded, almost black, so it no longer fits Kurata's description (Fig. 175). A hastate mark is visible on the abdomen and the legs show some signs of banding.

Description of female.—From Spring Creek Basin, Alberta. Carapace 2.30 mm long, 1.50 mm wide; color and markings of body and legs similar to the male. Anterior eye row much narrower than the posterior median row, strongly procurved, anterior median eyes larger than the anterior laterals, closer to the anterior laterals than to each other. Lower margin of the furrow of the chelicerae armed with three teeth, middle tooth the largest, the tooth nearest the base of the fang the smallest.

Legs 4123.

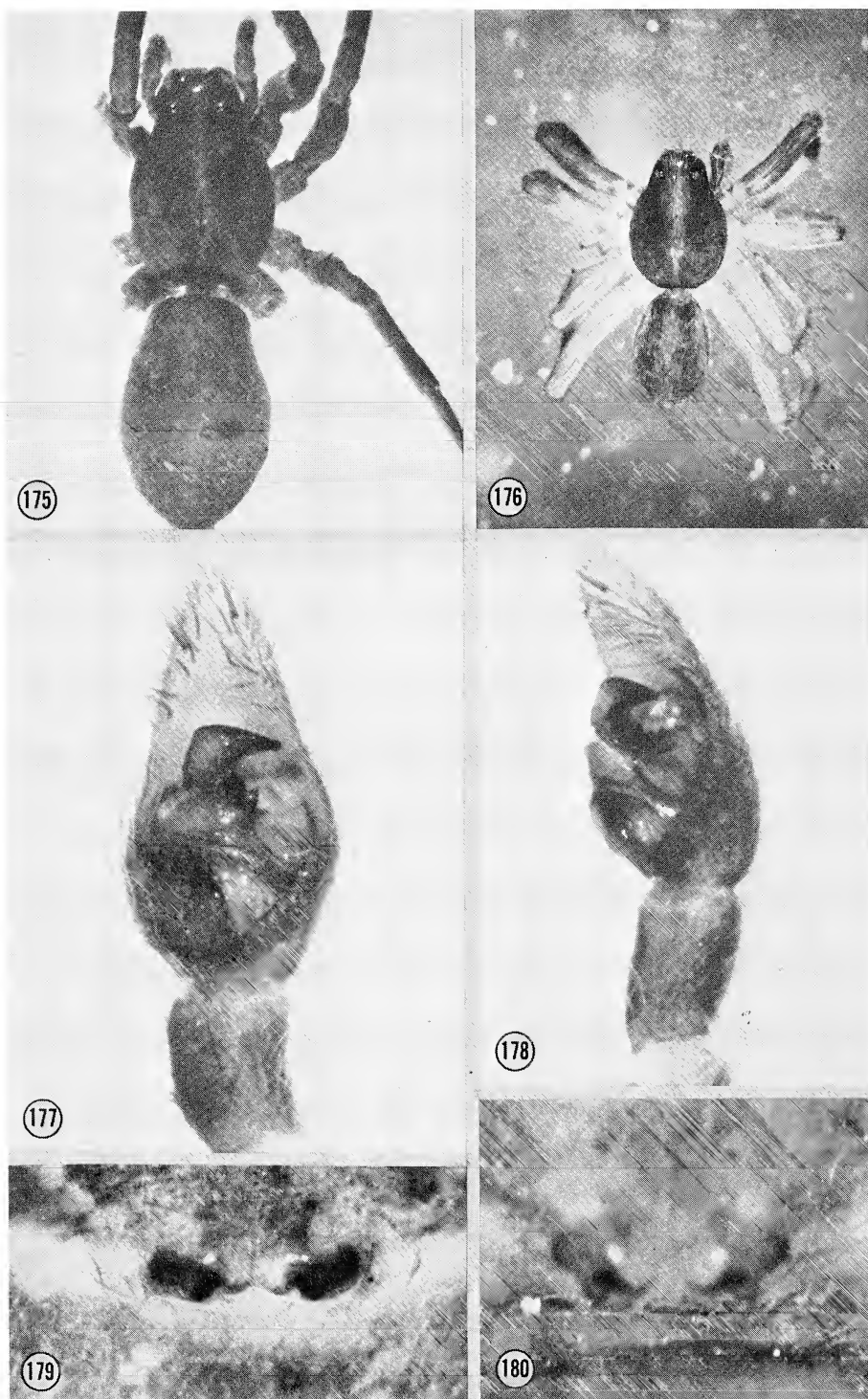
Description of male.—From Spring Creek Basin, Alberta, ca. 53° 30' N, 117° 40' W, 12-VI-1969. Carapace 2.20 mm long, 1.65 mm wide, almost black, shining with a sparse covering of white 'hairs' over the head region and around the lateral edge. Dorsum also almost black, with a sparse covering of short white 'hairs' which appear to be denser over the brown hastate mark; a pair of light colored spots behind the middle of the hastate mark and two pairs posterior to them. Sternum, epigastric region and venter almost black; anterior and posterior spinnerets almost black, posteriors twice as long as the anteriors. Labium and endites dark proximally, becoming yellow distally; coxae I dusky beneath, coxae II, III and IV yellow. Lower margin of the furrow of the chelicerae with three equally spaced teeth, middle tooth slightly larger than the medial, the tooth next to the base of the fang the smallest. Anterior eye row considerably narrower than the posterior median row, distinctly procurved; the anterior median eyes are larger than the anterior laterals and are nearer to them than to each other.

All palpal segments, except the tip of the cymbium, and femora, patellae and tibiae I and II dark like the carapace; femora I and II with a blue iridescence; all other leg segments lighter, basically yellow with dusky annulae.

Legs 4123.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.65	0.34	0.32		0.72	2.03
Leg I	1.38	0.68	1.13	1.20	0.80	5.19
Leg II	1.35	0.62	1.00	1.12	0.75	4.84
Leg III	1.33	0.55	0.93	1.25	0.70	4.76
Leg IV	1.85	0.70	1.53	2.03	0.97	7.08

Description of two males.—From Lady Lake, Saskatchewan. Carapace and dorsum black; dorsal head region with grey 'hairs.' Carapaces 2.05 mm long, 1.35 mm wide and 2.05 mm long, 1.55 mm wide. Anterior eye row narrower than the posterior median row, procurved. Sternum and venter black. All coxae and trochanters yellow ventrally; palpal



Figs. 175-180.—*P. bryantae*: 175, holotype female, Ontario; 176, male, Saskatchewan, Lady Lake; 177-178, palpus, Saskatchewan, Lady Lake; 179, epigynum, Canada, Alta; 180, holotype, epigynum, Ontario.

segments black, tip of cymbium light; femur I black beneath; femur II splotchy, femora III and IV yellow; patellae and tibia I and II black beneath, all other segments light; femur II dark distally, otherwise leg pattern is the same above and below.

Distribution.—Known only from Alaska and Canada.

Specimens examined.—*Alaska*: Fairbanks, July 68, John V. Mathews, female (R.E.L.). *Canada: Alberta*: ca 53° 30' N, 117° 40' W, D. W. Chomyn, VI-12-69, site I quad 1-6, male (R.E.L.), VI-12-69, site I, quad 1-2, female (R.E.L.), VI-5-69, site I quad 2-1, female (R.E.L.), VI-12-69, site 1 quad 2-2, 2 females (H.K.W.), VI-5-69, site 1 quad 1-6, male, 2 females (R.E.L.), VI-12-69, site 20 quad 20, male (R.E.L.), VI-5-69, site 1 quad 1-3, female (R.E.L.), VI-5-69, site 1 quad 2-10, female (R.E.L.), VI-12-69, site 1 quad 2-4, 2 males (H.K.W.); *Northwest Territory*: Wrigley Pan Trap no. 6, VI-6-12-69, G. E. Shewell, male female (R.E.L.), VI-12-15-69, male (R.E.L.); *Ontario*: Favourable Lake Mine, Lat. 53° N 94° W, June 1938, Morley Neal, female Holotype (R.O.M.Z. 7073); *Saskatchewan*: Lady Lake, June 9, 1969, D. J. Buckle, 2 males (D.J.B.).

Life history.—All the males and females from Canada were collected in June; the single female from Alaska in July.

Ecology.—The only information we have is the following from D. J. Buckle: “Logging trail through black spruce forest, Lady Lake, Saskatchewan, 9 June 1969.”

Pirata davisi, n. sp.
Figs. 181-186

Holotype.—Male, San Fernando, Tamaulipas, Mexico, Mar. 28, 1936, L. I. Davis (A.M.N.H.).

Allotype.—Female, with same data as holotype (A.M.N.H.).

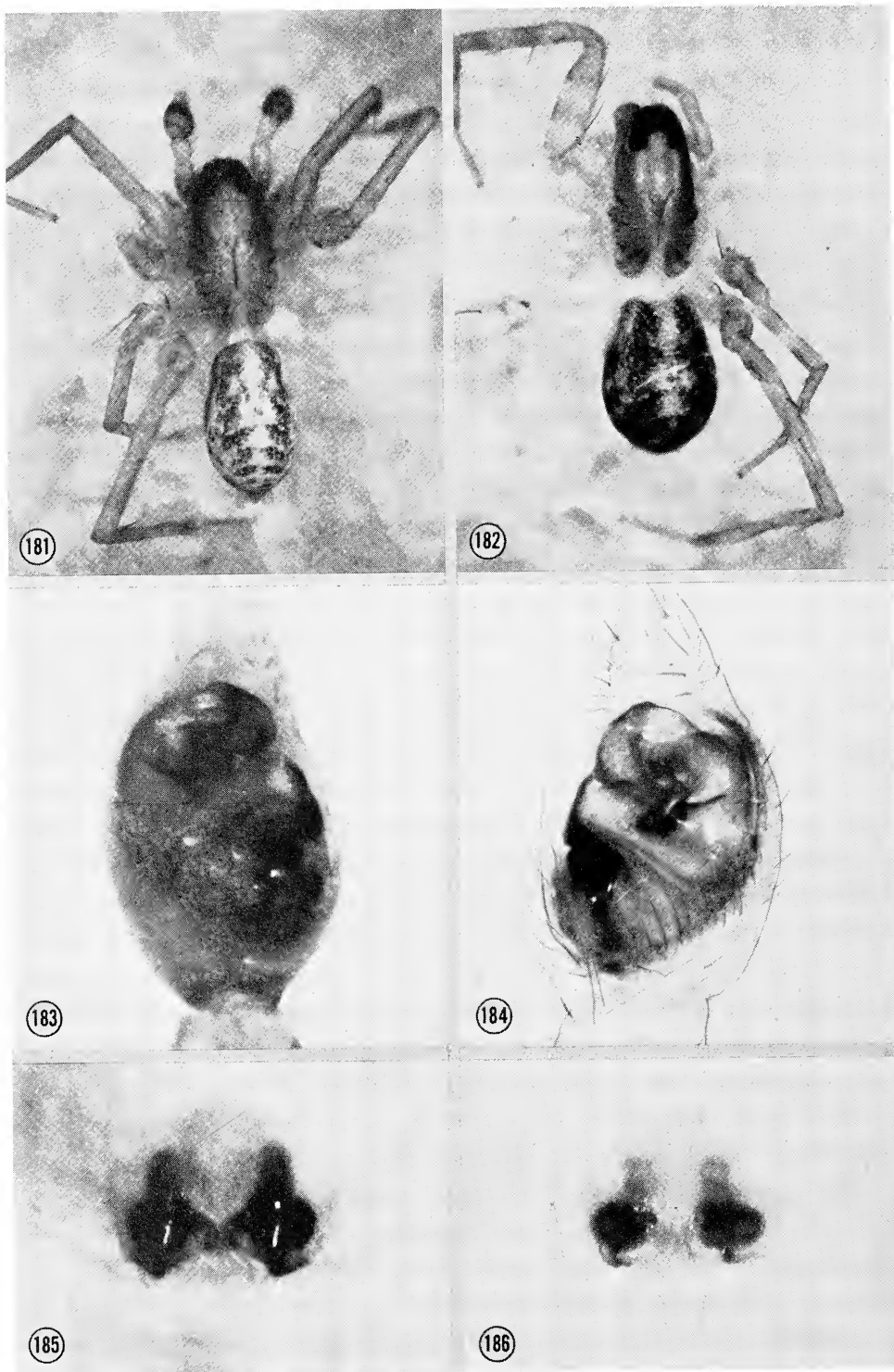
Diagnosis.—*Pirata davis*i, n. sp., is very similar in appearance to *P. turrialbicus*, n. sp., and is about the same in size. The epigynum, however, is more on the order of *P. aspirans*. The palpus resembles *P. turrialbicus* somewhat, but the median apophysis is relatively bulkier and the lateral process has a different shape (Figs. 183-184).

Description of holotype.—Carapace 1.72 mm long, 1.22 mm wide with a wide marginal light band and the typical tuning-fork pattern on the head (Fig. 181). Basic color light yellow, lateral margins of carapace without pigmented edge. Ventral surface of body yellow, unpigmented except for a small area in the middle of the venter. Lower margin of the furrow of the chelicerae with three teeth, the middle tooth the largest. Anterior eye row narrower than the posterior median row, procurved; the anterior median eyes are twice as large as the laterals; the anterior eyes are about evenly spaced.

Legs 4123, light yellow in color, without annulae. Tibia I with five long overlapping spines, three prolateral, two retrolateral.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.50	0.25	0.30		0.57	1.62
Leg I	1.25	0.55	1.07	1.17	0.60	4.64
Leg II	1.20	0.55	0.92	1.00	0.55	4.22
Leg III	1.10	0.50	0.80	1.07	0.50	3.97
Leg IV	1.60	0.57	1.37	1.97	0.70	6.21

Description of allotype.—Carapace 1.70 mm long, 1.22 mm wide, with a distinct tuning-fork pattern on the head and a wide marginal light area unmarked with pigment along the lateral edge. Basic color light yellow (Fig. 182). Sternum, labium and coxae



Figs. 181-186.—*P. davisi*, n. sp.: 181, holotype male, Mexico, Tamaulipas; 182, allotype female, Mexico, Tamaulipas; 183, palpus, Texas, Edinburg; 184, holotype, palpus; 185, epigynum, Texas, Edinburg; 186, epigynum, Texas, Bexar Co.

yellow, sternum with faint pigmented spots along lateral edges; venter a little darker with faint pigment in the middle.

Lower margin of the furrow of the chelicerae with 3 teeth, the middle tooth the largest. Anterior eye row narrower than the posterior median row, slightly procurved; anterior median eyes almost twice as large as the anterior laterals; anterior eyes about equally spaced.

Legs 4123, with faint annulae. Tibia I with 4 ventral spines; the two retrolateral spines long, overlapping, the two prolateral much reduced, the proximal one reduced to a bristle.

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.55	0.32	0.37		0.50	1.74
Leg I	1.25	0.60	0.92	0.97	0.51	4.25
Leg II						
Leg III	1.20	0.52	0.82	1.02	0.52	4.08
Leg IV	1.62	0.62	1.45	1.77	0.67	6.13

Distribution.—Mexico, Texas.

Additional records.—*Texas*: Edinburg, May 1, 1936, S. Muliak, 1 male, 2 females (A.M.N.H. ; Bexar Co., Bullis Hole, female Travis Co., Austin, R.V.C., female (M.C.Z.).

Life history.—Adult males and females have been collected on March 28 and May 1.

Pirata giganteus Gertsch

Figs. 187-191

Pirata giganteus Gertsch, 1934, Amer. Mus. Nov., 693:12-13. (female, Chicago, Illinois, A.M.N.H., examined).

Description of holotype.—A female with the typical tuning-fork mark on the head (Fig. 187). Carapace 3.2 mm long, 2.3 mm wide, sides "with a broad, irregular, marginal light band." Anterior eye row narrower than the posterior median row, slightly procurved; anterior median eyes closer to the anterior laterals than to each other, less than one diameter apart. Epigynum (Fig. 188).

Distribution.—Illinois, Wisconsin.

Specimens examined.—*Illinois*: nr Chicago, June 13, 1933, W.J.G., 2 female paratypes (A.M.N.H.); Princeton, June 12, 1933, T. H. Hubbell, male (A.M.N.H.); *Wisconsin*: Richland Co., Rt. 60 W of Gotham, June 17, 1949, H. Levi, female (M.C.Z.).

Life history.—All known specimens are from June.

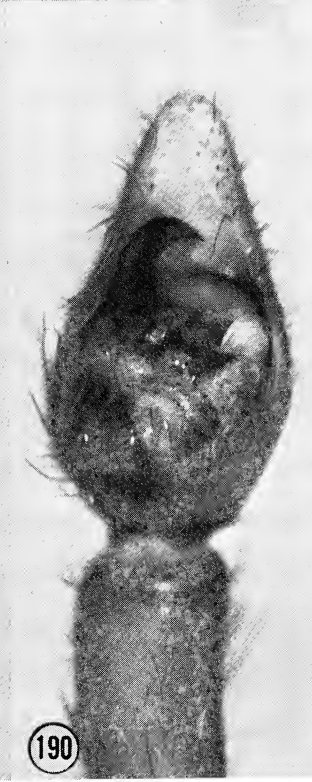
Remarks.—The carapace pattern of the Wisconsin female and the holotype are much like that of *P. sedentarius*. The epigynum resembles to some extent that of *P. hygrophilus* of Europe. The legs of the Wisconsin female show signs of annulae. Our measurements of the carapace of the holotype differ somewhat from Gertsch's; his are 3.0 mm long by 2.12 mm wide. He also describes the anterior eye row as straight, but it looks slightly procurved to us.

Pirata hiteorum, n. sp.

Figs. 192-198

Holotype.—Male, Cove Creek, Washington Co., Arkansas, June 2, 1963, Otis and Maxine Hite (A.M.N.H.).

Allotype.—Female with same data (A.M.N.H.).



Figs. 187-191.—*P. giganteus*: 187, holotype female, Illinois, Chicago; 188, holotype, epigynum; 189-191, palpus, Illinois, Princeton.

Etymology.—Named after the collectors, O. and M. Hite.

Diagnosis.—This small spider somewhat resembles *P. minutus* in appearance; however, the front legs are not dark in the male as they are in *P. minutus*. At first glance the epigynum looks like that of *P. minutus*, but close examination leaves no doubt as to their distinctness; the concave depressions in front of the tips of the lobes of the epigynum of *P. hiteorum* are unique. The palp resembles that of *P. aspirans* most closely, but the anteromedial truncation of the median apophysis (Figs. 194-195) is unique also. However, positioning of the palpus determines the shape of the median apophysis from the viewer's point of view and this palpus must be moved around carefully in order to obtain a satisfactory impression of its structure.

Description of holotype.—A male with basic color yellow or amber with dark pigment producing the typical tuning-fork pattern on the head and a distinct pattern on the dorsum (Fig. 192). Carapace 1.50 mm long, 1.03 mm wide, with a wide marginal light area and pigmented lateral edge. Eye region black. Legs yellow, lightly pigmented; femur I dusky above, palpal segments darker. Face, chelicerae, sternum, epigastric region, and venter all pigmented; venter splotchy. Anterior eye row distinctly narrower than the posterior median row, strongly procurved (Fig. 196). Anterior eyes about equally spaced, anterior median eyes approximately one and one-half times larger than the anterior lateral eyes. Clypeus height equals a diameter of an anterior median eye, slanted posteriorly (receding). Tibia and metatarsus I with three pairs of overlapping ventrolateral spines.

The legs from a male paratype from Cove Creek measure as follows:

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.43	0.20	0.24		0.47	1.34
Leg I	1.00	0.50	0.77	0.85	0.48	3.60
Leg II	0.93	0.43	0.70	0.75	0.45	3.26
Leg III	0.82	0.37	0.60	0.80	0.43	3.02
Leg IV	1.23	0.48	1.05	1.30	0.63	4.69

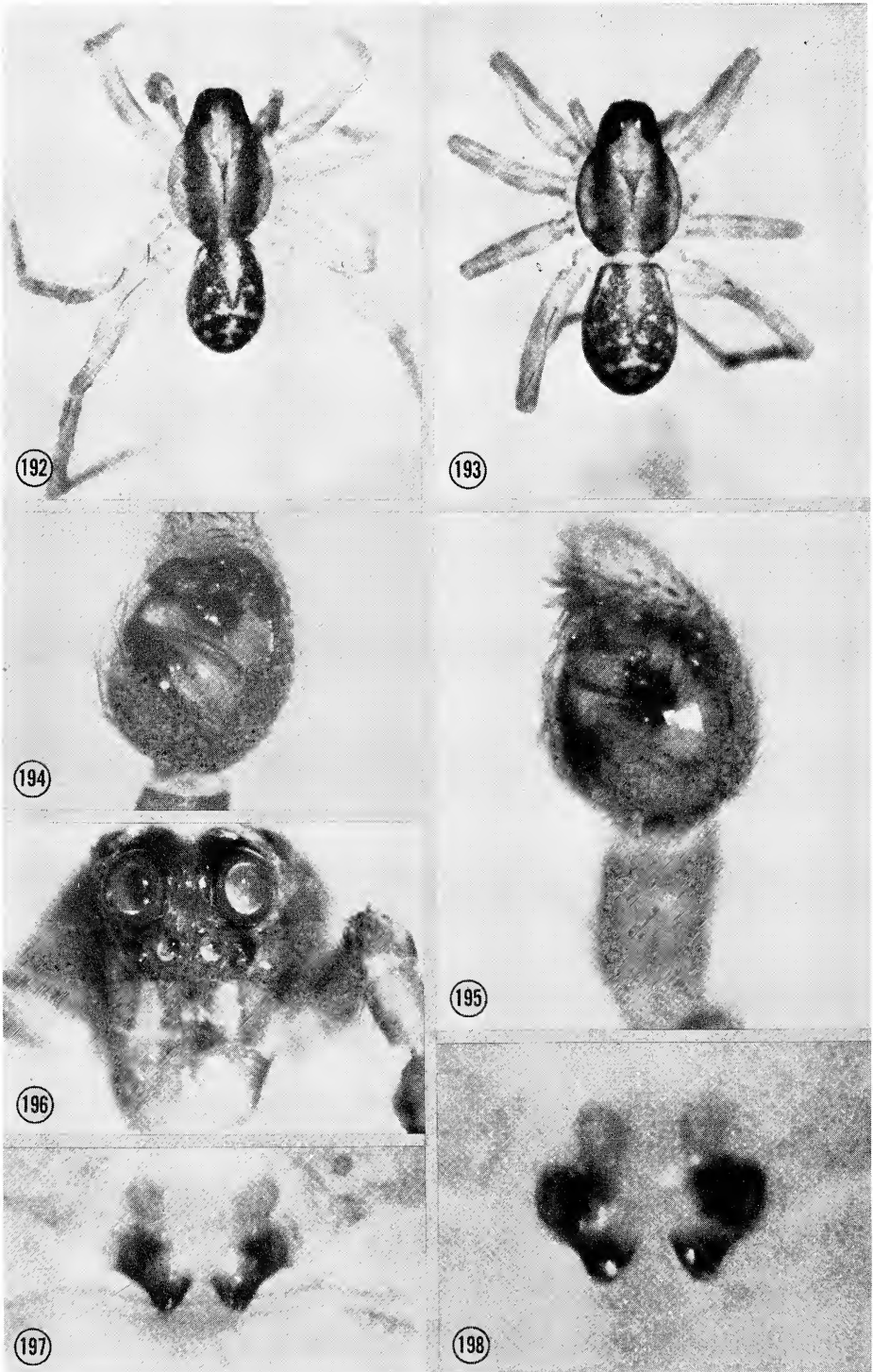
The lower margin of the furrow of the chelicerae of the paratype has three teeth, the middle tooth the largest, the one next to the fang inconspicuous.

Description of allotype.—The female is a little more heavily pigmented than the holotype (Fig. 193) and there is a distinct triangular dark spot that looks like a widening of the dorsal groove anteriorly; in front of this spot the two prongs of the tuning-fork pattern are lightly pigmented. The carapace is 1.50 mm long, 1.03 mm wide, and the pigment along the lateral edge is wider than in the holotype, so much so in fact, that one might describe the sides of the carapace as having a submarginal light area. In both sexes the carapace is shiny, somewhat as in *Trabea* and some *Arctosa*. The legs show faint traces of annulae. The eye arrangement (Fig. 196) and spining of tibia and metatarsus I are similar to the holotype.

Measurements of leg segments of a paratype from Cove Creek:

	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Palpus	0.50	0.25	0.33		0.47	1.55
Leg I	1.20	0.53	1.00	0.93	0.48	4.14
Leg II	1.10	0.50	0.83	0.85	0.47	3.75
Leg III	1.03	0.45	0.75	0.95	0.47	3.65
Leg IV	1.50	0.57	1.38	1.68	0.68	5.81

Lower margin of the furrow of the chelicerae with three teeth, the middle tooth the largest, the other two about equal in size; almost evenly spaced.



Figs. 192-198.—*P. hiteorum*, n. sp., Arkansas, Washington Co.: 192, holotype male; 193, allotype female; 194-195, palpus; 196, holotype, eyes; 197, allotype, epigynum; 198, epigynum.

Variation.—This species varies somewhat in the amount of pigmentation, in size, and in the structure of the genitalia. Sometimes leg I is slightly swollen and sclerotized in the male. Males vary in carapace length from 1.4 mm to 1.5 mm, females from 1.5 mm to 1.7 mm. The legs are lightly banded in dark specimens. The epigynum is characterized by the concavity in front of the tips of the lobes. The median apophysis varies somewhat in the shape of the median and lateral extensions or arms. The palpus is small and difficult to observe clearly, but it can be positioned so that the median apophysis appears squarely truncate laterally.

Distribution.—Southeastern United States, north to Virginia, west to Texas and north to Kansas.

Specimens examined.—*Alabama*: Madison Co., Monte Sano, Dec. 1940, A. F. Archer, female (A.M.N.H.); *Arkansas*: Benton Co., Beaver Lake, 7-VIII-65, Peck, female (Exline); V-21-65, male (Exline); Bradley Co., VI-1-63, female (Exline); Conway Co., V-30-64, MOR II, male (Exline); Crawford Co., Natural Dome, V-31-61, L-1-5, female and egg sac (Exline); Washington Co., Cove Creek, many records (Exline); *Florida*: Leon Co., Tall Timbers, male in May, female in June, pitfall (D.P.I.); *Kansas*: Riley Co., Manhattan, IX-5-63, female (Exline); *Missouri*: Dent Co., Dry Fork, VIII-22-62, HEF, 2 females (Exline); Phelps Co., Dry Forks Cr., VII-2-49, HEF, female (Exline); *North Carolina*: Orange Co., 7-VI-63, Beatty, male (Beatty); *Virginia*: Giles Co., Mountain Lake, July-August, males, females, egg sacs (D.P.I.); Albemarle Co., VIII-27-48, HKW, 3 females, egg sacs (H.K.W.); *Texas*: Dallas Co., Dallas, 11 May, 40, Knutsen, female (M.C.Z.).

Life history.—*P. hiteorum* is a summer species. Males have been collected from May to August with the majority from May and June. Most of the records of females are from August, but May, June and July are well represented. We have studied two females from March, three from September, and one from December. Egg sacs have been collected from May through August.

Ecology.—It is interesting that we have no record of *P. hiteorum* being taken near water. Most of the records are from pitfall traps or from under rocks. We have 14 records from pitfall traps in meadows, five from pitfall traps in old fields (most of these from Arkansas), one from a lawn at night, one from a hillside during the day, and the Texas record is from under a rock. Wallace collected this species at 4,000 feet at Mountain Lake, Virginia, at least a dozen times, almost always by turning rocks in fields or by scraping leaf litter and shining the area with a headlight in wooded situations, never close to water. This appears to be a mesic form.

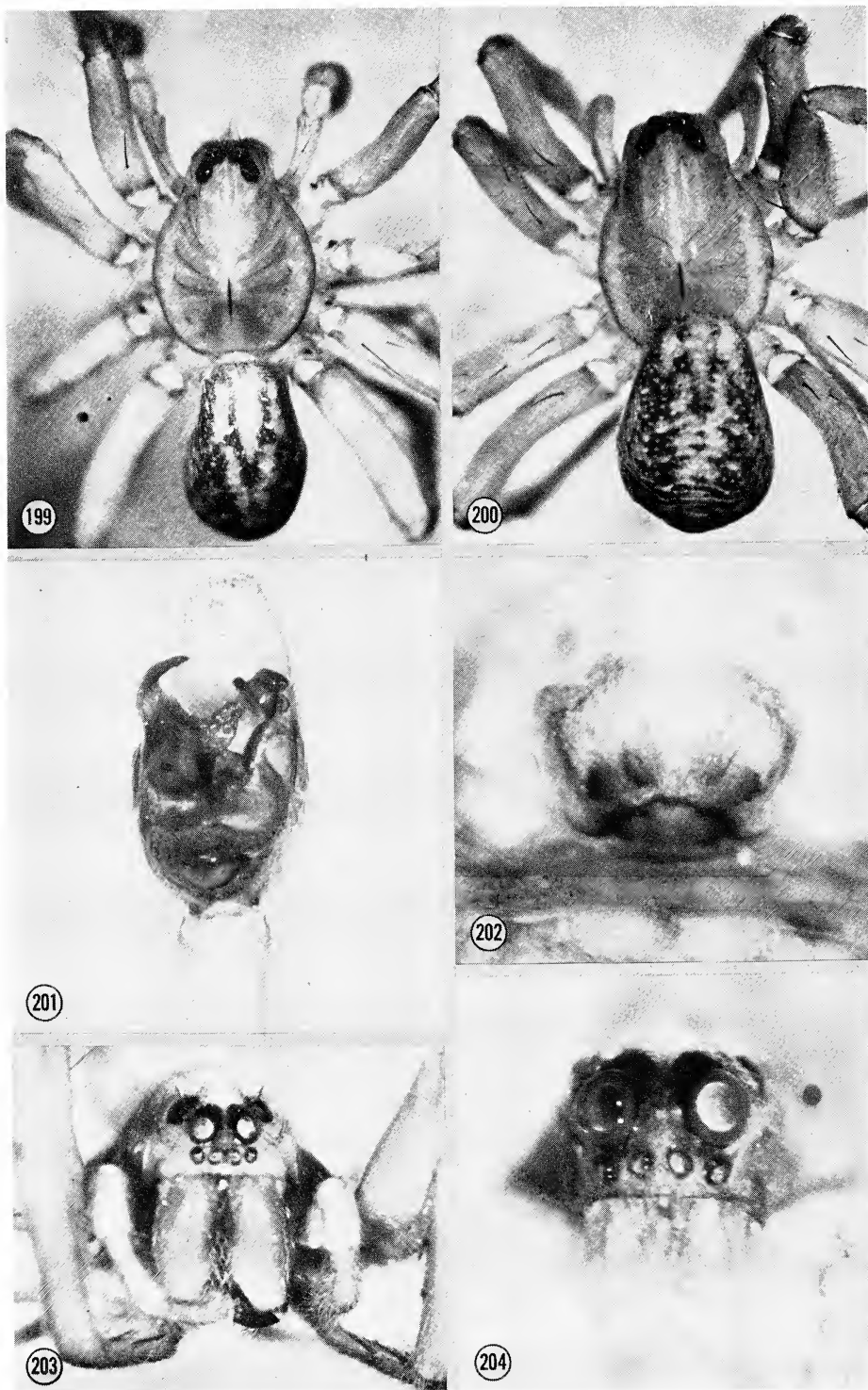
Remarks.—In publications on Arkansas spiders this species has been listed as *Pirata* sp. A., aff *minutus* Em).

Pirata marxi Stone

Figs. 199-203

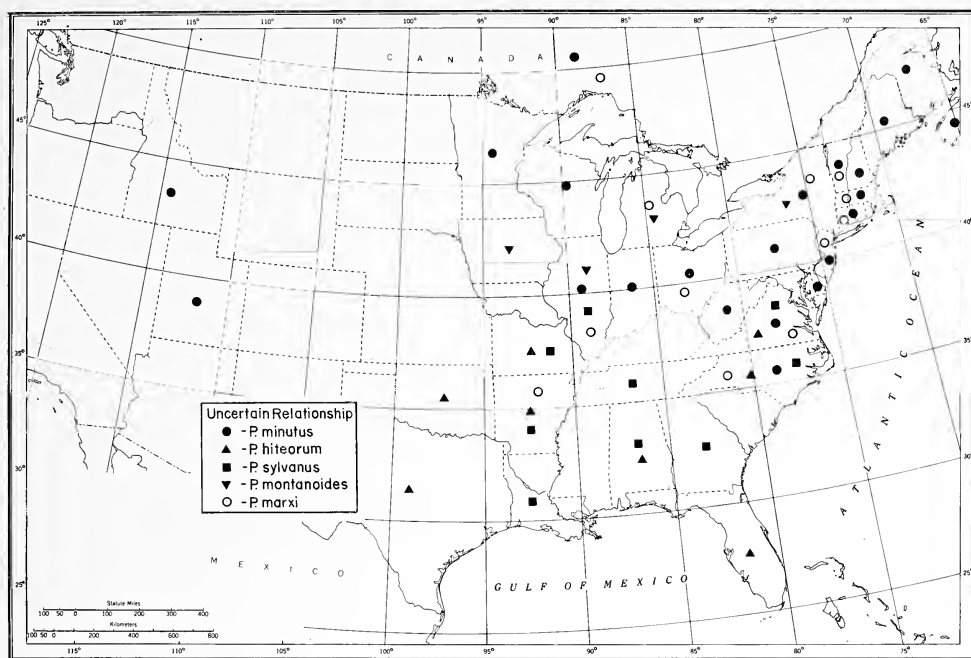
Pirata piraticus, Emerton, 1885, Trans. Connecticut Acad. Sci., 6:492, pl. 48, figs. 7-7d.

Pirata marxi Stone, 1890, Proc. Acad. Nat. Sci. Philadelphia, 42:429-430, pl. 15, figs. 1, 1a (female, York Co., Pennsylvania); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:307-309, pl. 21, fig. 8, pl. 22, fig. 8; Kaston, 1938, Canadian Entomol., 70:16, fig. 5; Kaston, 1948, Bull. Connecticut Geol. Nat. Hist. Survey, 70:309, pl. 49, figs. 985-986, pl. 50, fig. 1006.



Figs. 199-203.—*P. marxi*, New Jersey, Ramsey, VI-1-10-44: 199, male; 200, female; 201, palp; 202, epigynum; 203, female, eyes.

Fig. 204.—*P. hiteorum*, n. sp.: Allotype female, eyes.



Description of male.—From Ramsey, New Jersey, June 1-10, 1944, W.J.G. (A.M.N.H.). Carapace 3.2 mm long, 2.4 mm wide, with indistinct, wide submarginal light band and tuning-fork mark that is broken up into paired segments (Fig. 199). General body color in alcohol amber. Dorsum with distinct light-colored hastate mark bordered by black V-shaped mark which is bordered by light-colored converging stripes. Coxae, labium, sternum and endites without markings, venter with a little scattered pigment.

Anterior eye row narrower than the posterior median row slightly procurved; anterior median eyes a little larger than the anterior laterals, closer to each other than to the laterals. Height of the clypeus twice the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with two teeth.

Legs 4123, without annulae. Tibiae I and II with three pairs of ventrolateral spines, the distal pair apical in position, each with an additional prolateral spine about halfway between the middle and apical pairs. The prolateral spine of the proximal pair on tibia I barely overlaps the middle spine. The prolateral spines of the proximal and middle pairs on tibia II are reduced to about half the size of their mates.

Description of female.—From Ramsey, New Jersey, July 11, 1948, W. Ivie (A.M.N.H.). Carapace 3.5 mm long, 2.7 mm wide, with a rather indistinct submarginal light band and a narrow, light streak extending forward from the cervical groove to between the posterior lateral eyes (Fig. 200). For dorsum see the figure. Coxae, labium, endites and sternum without pigment.

Anterior eye row narrower than the posterior median row, slightly procurved; anterior median eyes about half again as large as the anterior laterals; anterior median eyes closer to each other than to the laterals. Height of the clypeus equal to the diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with two teeth, the largest near the base of the fang.

Legs 4123, without annulae. Tibia I and II with two pairs of non-overlapping ventrolateral spines, one apical ventroprolateral spine, and one prolateral spine distal to the

middle pair; the prolateral spine of the proximal pair reduced to a bristle. Metatarsus I and II with 3 pairs of ventrolateral spines, the distal pair subapical; metatarsus II also bears a spine on the midline between the distal pair; this spine is almost apical in position.

Distribution.—Eastern half of the United States and Canada; south into Florida.

Specimens examined.—Canada: *Ontario*; United States: *Arkansas*: Garland County; *Connecticut*: Fairfield, New Haven Counties; *Florida*: Alachua, Lake, Leon Counties; *Illinois*: Lake County; *Maine*: Swan Island; *Massachusetts*: Essex, Hampden, Middlesex, Nantucket Counties; *Michigan*: Calhoun, Clinton, Ingham, Livingston Counties; *New Jersey*: Bergen County; *New York*: Rensselaer, Saratoga, Schuyler, Nassau, Wayne Counties, Long Island; *North Carolina*: Durham County; *Ohio*: Hocking County; *Virginia*: Fairfax, Lancaster Counties; *Vermont*.

Life history.—This is evidently a rare species in the southern states. The only known males and females from Florida were collected in April. The other southern records are too few to warrant any conclusions. In the northern states there appears to be two broods per year. We have no records of adults from January, February or March; then both sexes for the next four months; no adults in August or September; males are present in October, and both sexes in November and December. The only egg sacs seen by us are from July.

Ecology.—In Florida this species is apparently confined to the leaf litter of wet, swampy, densely shaded areas, usually in a hammock along a stream. In Michigan *P. marxi* is found in swamps and bogs. In the New England and Middle Atlantic states this species inhabits similar situations and is also found in “wet” and “damp” fields. Emerton observed that it passed the winter in leaf litter in Massachusetts and Connecticut.

Remarks.—The pattern and size of *P. marxi* may vary somewhat. A male from Alachua Co., Florida, is larger than the male from New Jersey described above (carapace 3.6 mm long, 2.7 mm wide). Two females from Ramsey, New Jersey vary considerably in size (carapace no. 1, 3.5 mm long, 2.7 mm wide; carapace no. 2, 2.9 mm long, 2.1 mm wide) and somewhat in pattern, the markings on the larger specimen being less distinct than in the smaller. In old alcoholic specimens the pattern is sometimes obscure.

Pirata minutus Emerton

Figs. 208-216

Pirata minutus Emerton, 1885, Trans. Connecticut Acad. Sci., 6:493-494, pl. 48, figs. 10a-c (two males, West Roxbury, Massachusetts, June 2, 1872, J. H. Emerton, coll., M.C.Z., examined); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:301-303, pl. 21, fig. 9, pl. 22, fig. 7; Kaston, 1938, Canadian Entomol., 70:16, fig. 9; Kaston, 1948, Bull. Connecticut Geol. Nat. Hist. Survey, 70:307, pl. 50, fig. 1001, pl. 51, fig. 1008.

Pirata exigua Banks, 1892, Proc. Acad. Nat. Sci. Philadelphia, 44:72-73, pl. 1, fig. 48 (female, Ithaca, New York, M.C.Z., examined).

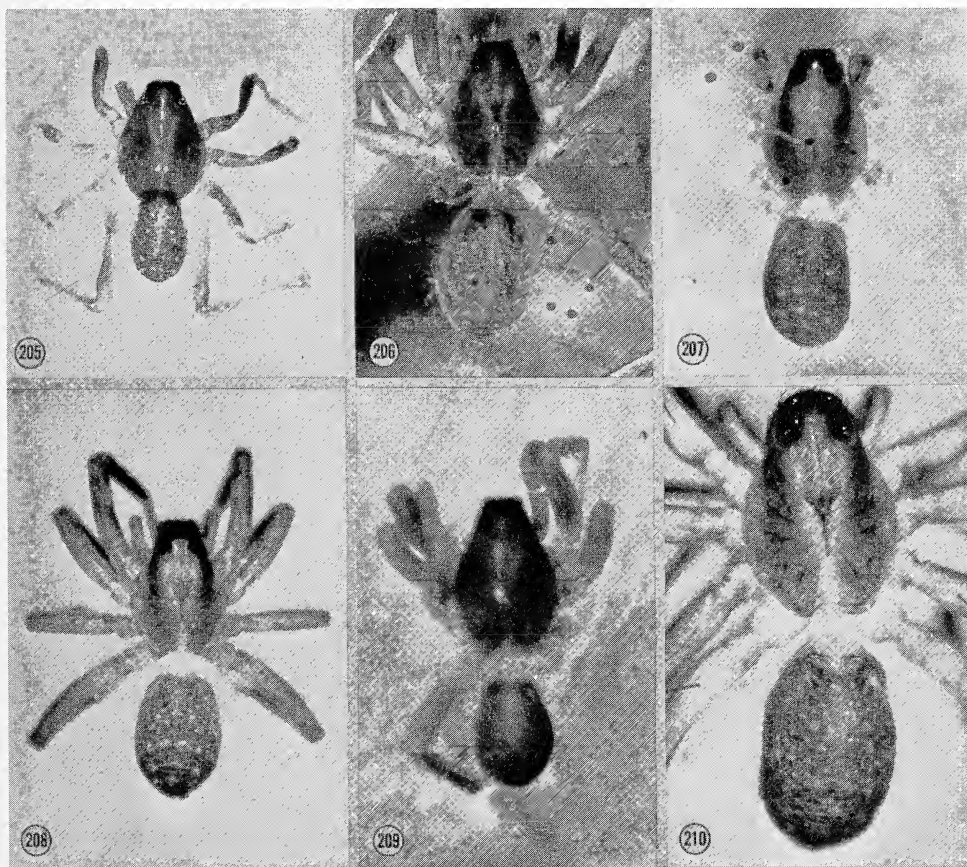
Pirata humicolus Montgomery, 1902, Proc. Acad. Nat. Sci. Philadelphia, 54:575-578, pl. 30, figs. 40-41 (male, female, Philadelphia, Pennsylvania, A.M.N.H., examined).

Remarks on synonyms and types.—Emerton (1885) gave Salem and Roxbury, Massachusetts, and Meriden, Connecticut, as the type localities for *P. minutus*. In May 1971 Dr. H. W. Levi sent to us as types two males, both faded, from West Roxbury, June

2, 1872, J. H. Emerton, collector. The label is underlined in red. In 1937 Wallace made these notes at the M.C.Z.: "*P. minutus* Em., Mass., Salem, June 25, 1877, J. H. Emerton, coll. female - Type is same as *P. exigua* Bks. male, 2 females in Type Bottle—same as *minuta* I have in my collection." The Salem specimens were not included in the M.C.Z. *Pirata* sent to us for examination. In any event, every specimen in the type series examined by us is *P. minutus* (Fig. 209).

The female type of *P. exigua* is labeled Ithaca, N.Y., and has all legs separated from the body. Banks' description and figure are not much help. His measurements of carapace differ from ours: 1.4 mm long by 0.9 mm wide, as opposed to ours of 1.75 mm long by 1.27 mm wide. The epigynum is *P. minutus* (Figs. 207, 215).

Montgomery recognized the similarity between his *P. humicolus* and *P. minutus* Emerton, but considered his species and *P. exiguus* Banks as distinct. He gives the length of the cephalothorax of the male as 1.7 mm, the female 1.8 mm. Wallace measured the types: male 1.5 mm, female 1.6 mm (Figs. 205-206). The male type has two teeth on the lower margin of the furrow of the chelicerae, the female type as three. Montgomery's figures of the genitalia are recognizable in both sexes.



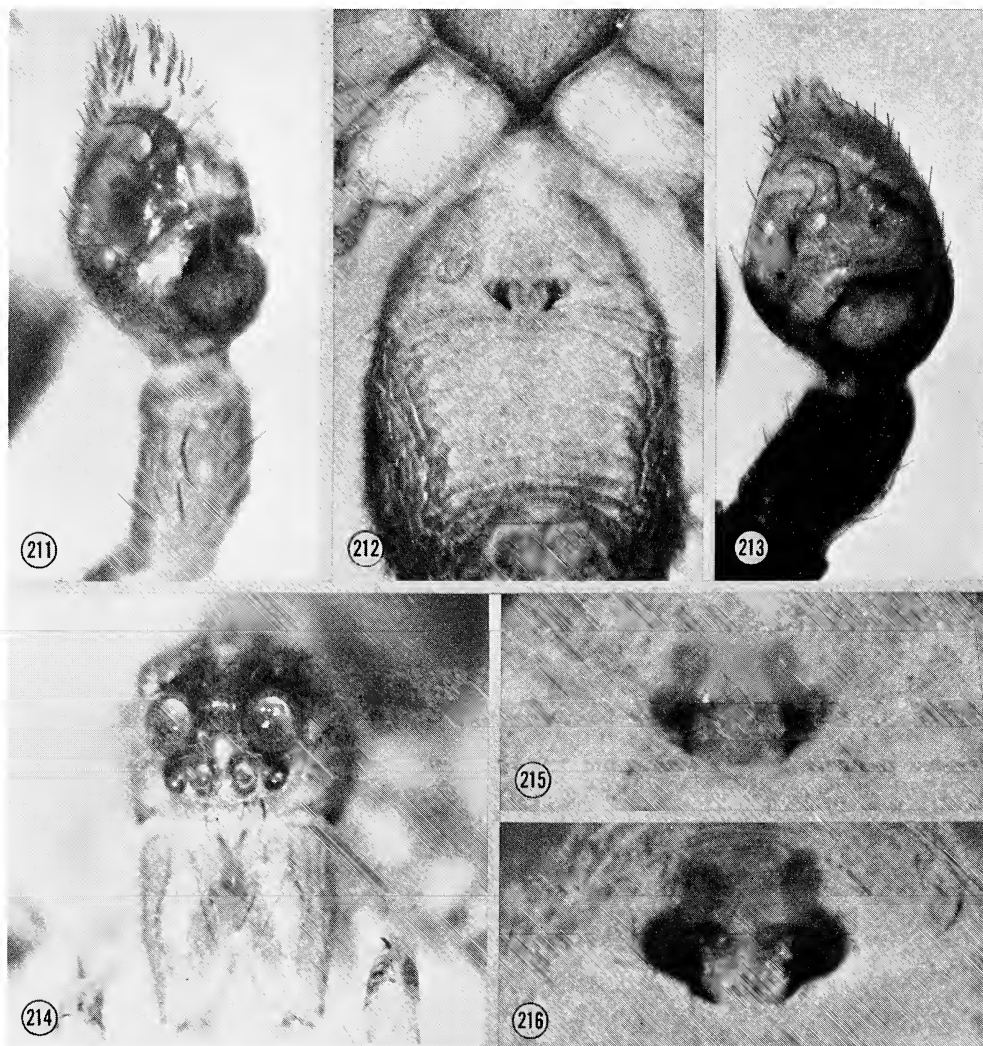
Figs. 205-206.—*P. humicolus*: 205, type male (= *P. minutus*), Pennsylvania, Philadelphia; 206, type female (= *P. minutus*), Pennsylvania, Philadelphia.

Fig. 207.—*P. exigua*: Type female (= *P. minutus*), New York, Ithaca.

Figs. 208-210.—*P. minutus*: 208, female, Michigan, Livingston Co.; 209, type female, West Roxbury; 210, female, Canada.

Data on type specimens.—From West Roxbury, Massachusetts. The large male has a carapace 1.5 mm long, 1.00 mm wide. The small male measures 1.37 mm long by 0.93 mm wide. The carapaces of both are dark and it looks like both had dark femora I. The anterior eye row is narrower than the posterior median row and is slightly procurved; the anterior median eyes are larger than the anterior laterals and are closer to the laterals than to each other.

Description of male.—From Livingston Co., Michigan. Carapace 1.45 mm long, 1.00 mm wide, dusky, with no tuning-fork pattern, lighter in front of cervical groove and along margins of carapace, but not presenting a distinct marginal light area sharply set off from the sides of the carapace. Dorsum dusky with pale hastate mark and indistinct paired



Figs. 211-212.—*P. minutus*: 211, palpus, Canada; 212, female, venter.

Fig. 213.—*P. humicolus*: Type male (= *P. minutus*), palpus.

Fig. 214.—*P. minutus*: Female, eyes, Michigan, Livingston Co.

Fig. 215.—*P. exigua*: Type female (= *P. minutus*), epigynum.

Fig. 216.—*P. minutus*: Epigynum, Michigan, Livingston Co.

spots posteriorly. Anterior eye row narrower than the posterior median row, procurved; anterior median eyes larger than anterior laterals, anterior eyes about equally spaced. Ventral surface unmarked except for medial longitudinal light stripe on sternum. Lower margin of furrow of chelicerae with three teeth; however, the tooth nearest the base of the fang is so small that under medium magnification only two teeth are visible.

Legs 4123, unbanded; femora I and II slightly darker than the other segments of the legs.

Description of female.—From Livingston Co., Michigan. Carapace 1.55 mm long, 1.07 mm wide; sides dusky with a narrow marginal light area, the tuning-fork pattern faint on head region; a triangular dark spot in front of cervical groove with its apex at the groove. Dorsum mottled with five pairs of white spots that look like they were covered with white scales in life. Venter, coxae, labium, endites yellow; sternum with a median longitudinal light stripe. Lower margin of furrow of chelicerae with three teeth; however, the tooth next to the base of the fang is so small that under medium magnification only two teeth are visible. Anterior eye row straight, narrower than the posterior median row; anterior median eyes are twice as large as the anterior laterals; the anterior eyes are equally spaced. Clypeus receding, equal in height to the diameter of an anterior median eye.

Legs 4123, dusky, without annulae. Femur I and II darker than the others, iridescent on prolateral surface.

Variation.—There is some variation in size and appearance. A male from Michigan has a carapace 1.52 mm long, 1.07 mm wide; its femora I and II and palpal segments are dark. The sides of the carapace are dark and there is no marginal band; the venter is dusky.

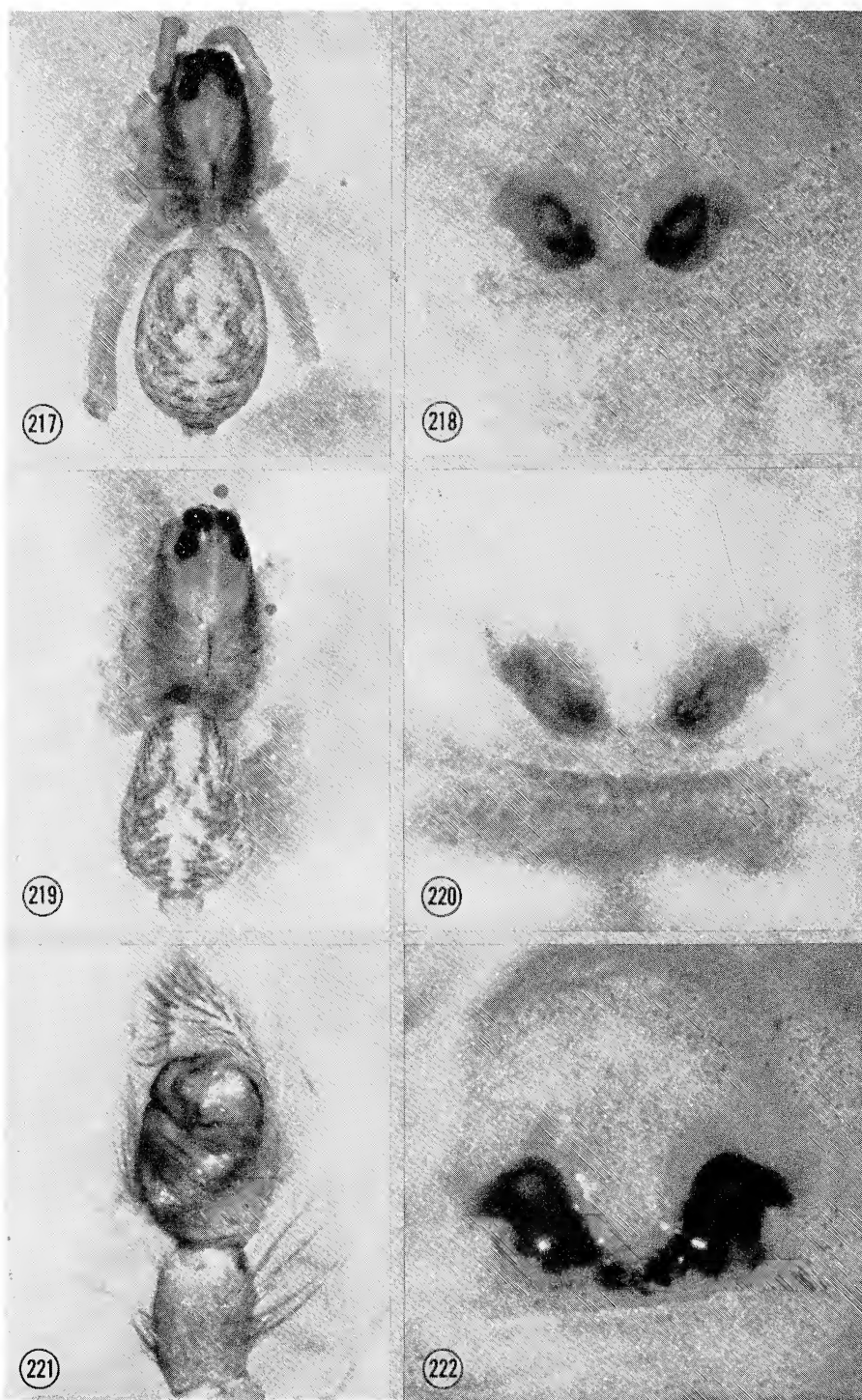
A male from Ontario is larger, carapace 1.62 mm long, 1.20 mm wide. The sides of its carapace are dark with a very thin marginal light area. Femora I and II and palpal segments are dark. There are three pairs of ventral spines on tibia I and the apical spines are reduced to minute hairs. The venter is dusky; the sternum is dusky with a median light streak. The anterior eye row is narrower than the posterior median row and slightly procurved.

A female from Ontario has a carapace 1.50 mm long, 1.05 mm wide. The carapace is dusky like *P. montanus* and has a narrow marginal light area. The anterior eye row is narrower than the posterior median row and is slightly procurved. There are three pairs of ventral spines on tibia I; the legs are yellow, without annulae; the venter is dusky, the sternum is dusky with a median light streak.

In dark females all legs may be dark distally with proximal ends of femora lighter.

Distribution.—Northeastern United States and Canada; south to North Carolina, west to Minnesota. Gertsch and Davis (1940) reported it from Mexico, but we have seen no specimens from south of North Carolina; since they were juveniles it is very likely that they were something else.

Specimens examined.—Canada: *New Brunswick*: June 17-24, 63, two males, July 10, 68, 2 females, egg sacs, T. R. Renault; *Nova Scotia*: Barrington, IX-23, Bryant, female (M.C.Z.), Canard, June 27, 56, C.D.D., 5 males (C.D.D.), Cow Bay, June 15, 1960, Fox and Sawler, 2 males, female (C.D.D.); *Ontario*: Bruce, Middlesex, Nippissing, Ontario, Prince Edward, York Counties, Elmhurst Beach, Rednersville, Chatterton, St. Joseph Island. United States: *Connecticut*: Fairfield, New Haven Counties, Brooksville; *Delaware*: Wilmington, A. Bacon, male (A.M.N.H.); *Idaho*: Adams Co., Mesa, July 2, 1943, W. Ivie, males, females (Utah); *Illinois*: Montgomery Co., Farmersville, 6-1-33, W.I., male (Utah), Arlington Heights, VI-36, F. Schubel, male (D.C.L.); *Indiana*: Lake Co., Gary,



Figs. 217-222.—*P. montanoides*: 217, female type no. 1, New York, Ithaca; 218, female type no. 1, epigynum; 219, female type no. 2, New York, Ithaca; 220, female type no. 2, epigynum; 221, palp, Iowa, Cerro Gordo Co.; 222, epigynum, Michigan, Utica.

6-16-33, W.I., female (Utah); *Maine*: Cumberland, Hancock Counties; *Massachusetts*: Essex, Middlesex, Nantucket Counties, Allston; *Michigan*: Calhoun, Charlevoix, Clinton, Ingham, Kalamazoo, Livingston, Menominee, Midland, Washtenaw, Wayne Counties, Douglas Lake; *Minnesota*: Freeborn, Marshall, Ramsey, Sant Luis Counties; *New Hampshire*: Coos, Frafton Counties, Mt. Washington; *New Jersey*: Bergen County, Grosswicks; *New York*: Albany, Chautauqua, Columbia, Essex, Fulton, Monroe, Nassau, Rensselaer,

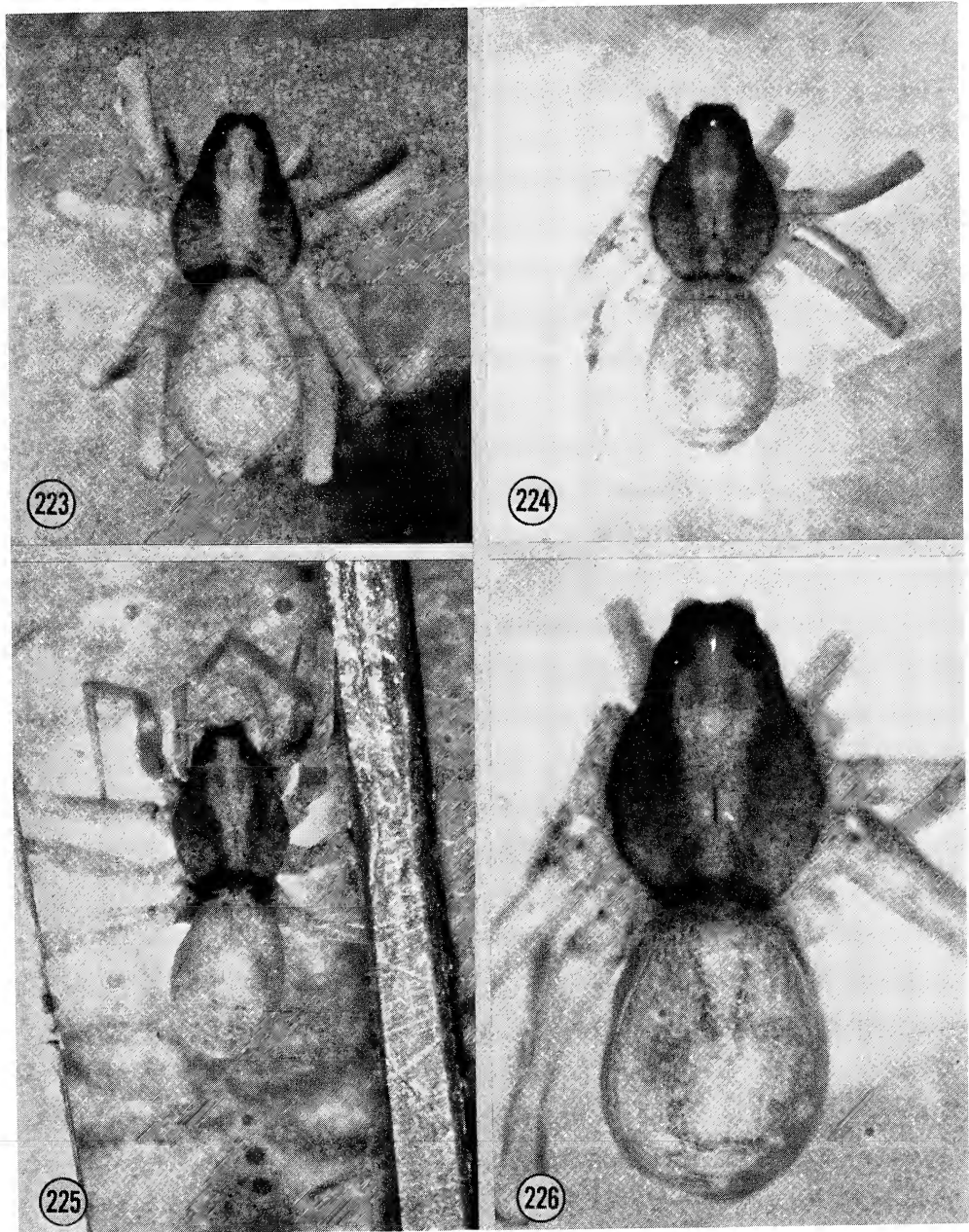


Fig. 223-224.—*P. agilis*: 223, juv. type male (= *P. montanus*), New York, Ithaca; 224, type female (= *P. montanus*), New York, Ithaca.

Figs. 225-226.—*P. elegans*, female co-type (= *P. montanus*), Pennsylvania, York.

Tompkins Counties, Wells, Dormansville, Enfield Glen, Cold Spring Harbor, Cross Lake; *North Carolina*: Avery Co., Pineola, N. Banks, VII-14-03, male (M.C.Z.); Watermount, 7-8-10, R.V.C., 77:34 NW, female (Utah); *Ohio*: Ashtabula, Guernsey, Wayne Counties; *Pennsylvania*: Cambria, Potter, Westmoreland Counties; *Tennessee*: Roane Co., 7-12-33, W.I., male, females (Utah); *Utah*: Cache Co., 1 mi. S. Logan, 7-1-27, R.V.C., female (Utah); Emery Co., Ferron, 6-23-34, W.I. and H.A.R., female (Utah); *Vermont*: Lamoille County; *Virginia*: Giles, Montgomery Counties; *West Virginia*: Mercer, Pocahontas Counties; *Wisconsin*: Eau Claire, Iron, LaCrosse, Marinette, Rock, Walworth, Winnebago Counties, Point Comfort.

Life history.—Adult males and females are present in the northeastern states from May through September; in Canada from June through September. Females with egg sacs are present from June through September. "This species apparently overwinters half-grown, and matures in late May and early June" (Kaston, 1948, p. 307).

Ecology.—*P. minutus* is not restricted to aquatic situations. In northwestern New Brunswick it was collected in pitfalls in a spruce-fir forest and under stones; in Nantucket, Massachusetts, in a salt marsh. In Michigan it has been taken in swamps, in *Typha* marsh, in a rotten log in upland field, and running on the steps of a house in upland field; in New York on the summit of Mt. Marcy. At Mountain Lake, Virginia, Wallace collected *P. minutus* on numerous occasions, and often in the company of *P. hiteorum*, n. sp., by turning rocks, logs, etc., in meadows and old fields; also on moist road banks and seepage areas. Levi and Field (1934) reported *P. minutus* as "fairly common" in Wisconsin, "usually in woods." Chamberlin (1908) said it occurred in "damp meadows, margin of ponds. Egg sacs late in summer."

Remarks.—This species has been misidentified frequently. We have found it labeled as *P. montanus*, *P. arenicola*, *P. montanoides*, *P. insularis*, *P. sylvestris*, *P. exiguus*, and *P. febriculosa*. *P. hiteorum* has been identified as *P. minutus* and at Mountain Lake, Virginia, they occur in the same field. Since they look very much alike, are of about the same size, and have epigyna that resemble each other somewhat, they can be confused easily. However, they differ in the following ways: *P. minutus* has a narrow marginal light area on the carapace and the front legs are dark, whereas *P. hiteorum*, n. sp., has a wide marginal light area on the carapace and the front legs are not dark; *P. minutus* usually has two teeth on the lower margin of the furrow of the chelicerae and *P. hiteorum*, n. sp., usually has three, but this is not a constant character. They differ in the structure of both palpus and epigynum; this can best be checked by referring to the illustrations (Figs. 194-195, 197-198, 211, 216). The *P. hiteorum* epigynum has a pair of posteriorly pointed projections somewhat like *P. suwaneus* and the palpus has a median apophysis of the *P. aspirans* type, while the *P. minutus* epigynum lacks posterior projections and the median apophysis is a curved tooth somewhat like that in *P. insularis*.

Pirata montanoides Banks

Figs. 217-222

Pirata montanoides Banks, 1892, Proc. Acad. Nat. Sci. Philadelphia, 44(1):71-72, pl. 1, fig. 46 (two females, Ithaca, New York, M.C.Z., examined).

Remarks.—The two type females from Ithaca, New York, differ in size: no. 1 carapace is 1.75 mm long, 1.27 mm wide; no. 2 carapace is 2.0 mm long, 1.5 mm wide.

Diagnosis.—A small, pale species with a wide marginal light area on the carapace, comparable to *P. minutus* in size, but differing in pattern and genitalia. The male has a long, tapering median apophysis bent at a 110 degree angle and extending beyond the alveolus (Fig. 221). The epigynum is quite distinct (Fig. 222) although it has a shape somewhat like that of *P. minutus*. The lower margin of the furrow of the chelicerae has two teeth and both sexes lack ventral distal spines on tibiae I.

Description of type female no. 1.—Carapace yellow with wide marginal light area, lateral edges clear yellow, without pigment. Tuning-fork mark indistinct and interrupted on head region. Dorsum yellow with grey markings (Fig. 217). Sternum yellow, immaculate. Legs (mostly disarticulated) yellow, indistinctly annulate. Venter yellowish with grayish markings behind the middle.

Anterior eye row narrower than the posterior median row, procurved, anterior eyes equally spaced, the medians a little larger than the laterals. Anterior lateral eyes a radius from the edge of the clypeus. Lower margin of the furrow of the chelicerae with two teeth, the one nearest the fang the largest. Tibiae I with three pairs of ventral spines, third pair nearly lateral, none distal. For epigynum see Fig. 218.

Description of male.—From Cerro Gordo Co., Iowa. Length 3.0 mm, carapace 1.6 mm long, 1.2 mm wide, with a wide marginal light area as in the female. Sternum and mouth parts clear yellow; legs with faint annulae. Venter dirty yellow with median pale gray streak. Lower margin of the furrow of the chelicerae with two teeth.

Legs 4123. Tibiae I with three pairs of long spines as in the female, without distal spines. Eyes as in the female except that the anterior lateral eyes are a little farther from the edge of the clypeus. Palpus short with patella and tibia about equal in length and not much longer than broad. Cymbium 0.52 mm long, 0.27 mm wide; palpal tibia 0.23 mm long, 0.21 mm wide.

Distribution.—Illinois, Iowa, Michigan, New York.

Specimens examined.—*Illinois*: nr Chicago, June 10, 1933, W.J.G., female, egg sac (H.K.W.); *Iowa*: Cerro Gordo Co., nr Clear Lake, 14 June 61, H. Levi, male (M.C.Z.); *Michigan*: Utica, VIII-3-36, M. N. Hatch, 4 females (Exline); *New York*: Ithaca, Banks, 2 females (M.C.Z., types).

Life history.—The only known male is from June; females are from June and August; the only egg sac is from June.

Ecology.—Nothing is known except that the male came from "McIntosh Woods" near Clear Lake, Iowa.

Remarks.—Every specimen examined had two teeth on the lower margin of the furrow of the chelicerae. The females from near Chicago are discolored and so dark that the pattern is not discernable.

Pirata montanus Emerton

Figs. 223-232

Pirata montanus Emerton, 1885, Trans. Connecticut Acad. Sci., 6:493, pl. 48, fig. 9 (three females, New York, M.C.Z., examined; see comments); Chamberlin, 1908, Proc. Acad. Nat. Sci. Philadelphia, 60:306-307, pl. 10, fig. 9, pl. 22, fig. 9; Kaston, 1938, Canadian Entomol., 70:16, fig. 6; Kaston, 1948, Bull. Connecticut Geol. Nat. Hist. Survey, 70:308, pl. 49, fig. 983, pl. 50, fig. 1004, pl. 51, fig. 1009.

Pirata elegans Stone, 1890, Proc. Acad. Nat. Sci. Philadelphia, 42:429, p. 15, figs. 5, 5a (female cotype, York Co., Pennsylvania, A.M.N.H., examined).

- Pirata agilis* Banks, 1892, Proc. Acad. Nat. Sci. Philadelphia, 44:72, pl. 1, fig. 47 (male, female, 2 juv., Ithaca, New York, M.C.Z., examined; see comments).
- Pirata nigromaculatus* Montgomery, 1902, Proc. Acad. Nat. Sci. Philadelphia, 54:579-581, pl. 30, figs. 44-45 (male, female, Luzerne Co., Pennsylvania, A.M.N.H., only female cotype examined; see comments).
- Pirata montana*, Emerton, 1911, Trans. Connecticut Acad. Arts, Sci., 16:401, 402, pl. 5, figs. 3, 3a.

Comments on synonyms and types.—The vial sent to us as containing the type of *P. montanus* contains two females labeled “Long Lake, Adirondacks, July 1884, J. H. Emerton, coll., dried up, relaxed 1958.” These are evidently the two females cited by Emerton from Long Lake and are what we recognize as *P. montanus*.

Banks described and gave measurements of a female *P. agilis*, n. sp. A vial sent to us from the M.C.Z. contains one male, one female, and two immature specimens labeled in longhand, “*Pirata agilis* Bks type,” Ithaca, New York. All four specimens are *P. montanus*.

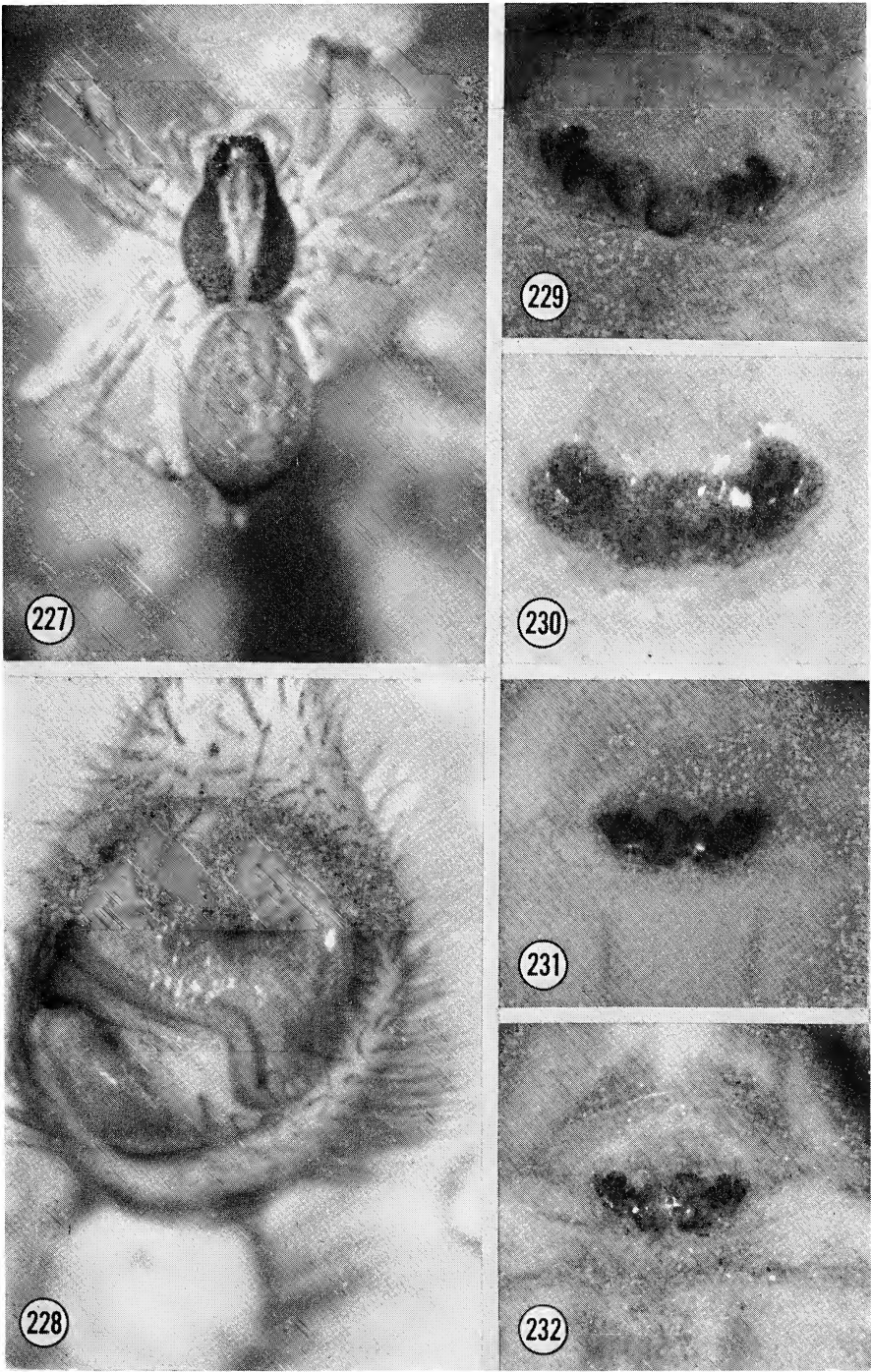
The types of *P. nigromaculatus* Montgomery were not received. However, in the shipment of types from the A.M.N.H. there was a female from Pennsylvania labeled “Cotype” with a carapace 2.7 mm long by 1.77 mm wide which is clearly *P. montanus*.

Description of female.—From Poverty Bay, Canada. Carapace 3.0 mm long, 2.1 mm wide, with a wide dorsal light colored band that extends from the posterior margin of carapace, becoming wider as it approaches the posterior lateral eyes and enclosing a tuning-fork mark which is incomplete, i.e., broken up into four patches of pigment; sides heavily pigmented with no trace of marginal or submarginal light areas. General body color amber in unpigmented areas; dorsum pigmented with indistinct hastate mark; legs unbanded. Ventral surfaces of body and legs unmarked. Lower margin of the furrow of the chelicerae with three stout teeth which are almost equal in size. Anterior row of eyes distinctly procurved, much narrower than the posterior median row; anterior eyes almost equal in size, equally spaced; clypeus height at anterior lateral eyes equal to the diameter of an anterior lateral eye.

Legs 4123.

Description of male.—From Raleigh Co. W. Va. Carapace 2.3 mm long, 1.7 mm wide; sides black; a wide mid-dorsal light stripe extends from the posterior margin to the posterior lateral eyes, widening to inclose the tuning-fork pattern in the head region; the head region bears a sparse covering of white hair-like structures which are longest between the posterior median eyes; the lateral edges of the carapace are adorned with closely set, short white hair-like bristles. The dorsum of the abdomen has an indistinct hastate mark, lateral rows of white scales, and four pairs of spots covered with white scales. Lower margin of the furrow of the chelicerae with three robust teeth which are almost equal in size. Anterior eye row distinctly procurved and considerably narrower than the posterior median row; anterior eyes almost equal in size and evenly spaced. Sternum, labium, endites and coxae I and II pigmented; sternum with a median longitudinal light stripe; distal end of endites light colored. Venter anteriorly, and epigastric region, darkly pigmented.

Legs 4123. The legs are yellow above except for coxae I and II and proximal five-sixths of femora I and II which are almost black, and femora III and IV which have a lightly pigmented band near the distal end. The leg pattern is the same below except that the pigment on femora I and II covers the whole surface.



Figs. 227-229.—*P. montanus*: 223, female, Virginia, Dickerson Breakes St. Pk.; 228, palpus, Connecticut, E. Haddon; 229, epigynum, Connecticut, E. Haddon.
Fig. 230.—*P. agilis*: Type (= *P. montanus*), epigynum.
Fig. 231.—*P. nigromaculatus*: Cotype (= *P. montanus*), epigynum.
Fig. 232.—*P. elegans*: Cotype (= *P. montanus*), epigynum.

Distribution.—Northeastern United States and Canada; south into North Carolina; west into Iowa and Minnesota.

Specimens examined.—Canada: *Nova Scotia, Ontario*. United States: *Connecticut, Indiana, Kentucky, Massachusetts, Michigan, New Hampshire, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, Wisconsin*.

Life history.—Ninety-two percent of the specimens we have examined are from May, June, July and August. It is striking that we have not seen a single specimen from December, January, February, March or April and only one collection each from October and November. We have males only from May, June and July and egg sacs from June, July, August and September.

Ecology.—The small amount of evidence available indicates that *P. montanus* occupies a variety of habitats from sphagnum moss in a bog to leaf litter on a mesic slope. Wallace collected it sifting leaf litter on a mesic slope in Magnetawan, Ontario. Levi and Field (1954) reported it in Wisconsin "in forests, frequently on hills. Fairly common." The following notes were extracted from labels in vials: Michigan: "sphagnum in bog," "leaf litter-wood lot." Pennsylvania: "can trap-woods." Virginia: "leaf mould of spruce, hemlock, oak mesic forest," "sphagnum moss-spruce swamp," "laurel thicket," "moss on rock at bank of stream." Wisconsin: "maple woods," "under rotten pine log." Stone (1890) wrote that *P. elegans* was "rather abundant in damp woods in York Co., Pennsylvania, in June."

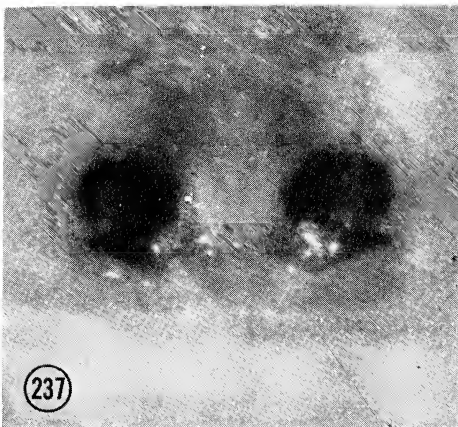
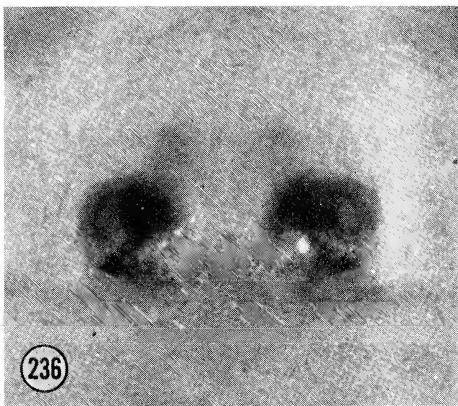
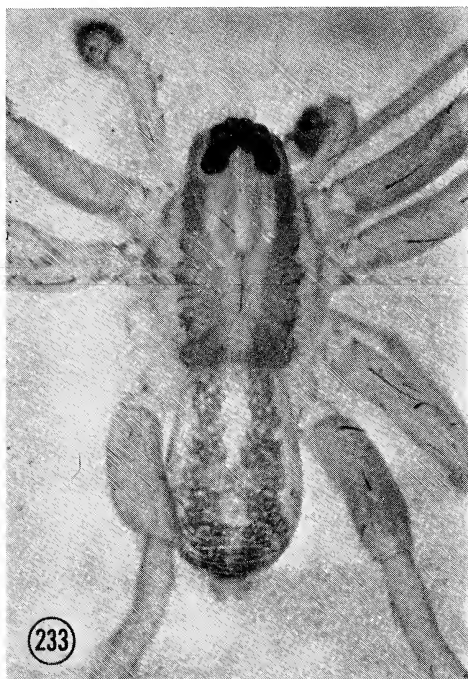
Remarks.—*Pirata montanus* is one of the easiest *Pirata* to recognize due to the unique pattern on the carapace and the unique genitalia. It is one of the few *Pirata* that lack a light marginal or submarginal band on the carapace.

Pirata sylvanus Chamberlin and Ivie
Figs. 233-237

Pirata sylvanus Chamberlin and Ivie, 1944, Bull. Univ. Utah, 35(9):151-152, figs. 192, 193 (male, female, 2 mi. E. of Sylvania, Georgia, A.M.N.H., examined).

Remarks on types.—The male holotype has a carapace 1.90 mm long, 1.50 mm wide, with a submarginal light band (Fig. 233). The femora are faintly banded. The anterior eye is narrower than the posterior median row and is slightly procurved; the anterior median eyes are twice as large as the laterals and the eyes are almost equally spaced. The carapace of the female allotype is 2.37 mm long, 1.75 mm wide, with a submarginal light band. The eye arrangement is similar to that of the holotype except the anterior median eyes are closer to the laterals than to each other.

Description of male.—From Morrilton, Conway Co., Arkansas, 14 June 1961. Carapace 1.93 mm long, 1.35 mm wide, with a wide marginal light band and tuning-fork pattern. (Note: This male and one of the other two males in the same vial have a trace of marginal pigment and the male in the same vial with the female described below has a definite submarginal light band on the carapace.) Dorsum of abdomen heavily pigmented, with light hastate area and indications of paired light spots. Coxae and endites light amber, unpigmented; labium and venter lightly pigmented; sternum light with marginal blotches of pigment. Anterior eye row narrower than the posterior median row, almost straight; anterior median eyes twice as large as laterals, closer to laterals than to each other. Clypeus about as high as the diameter of an anterior median eye. Lower margin of the



Figs. 233-237.—*P. sylvanus*: 233, holotype male, Georgia, 2 mi. E. Sylvania; 234, allotype female, Georgia, 2 mi. E. Sylvania; 235, holotype, palpus, 236, allotype, epigynum; 237, epigynum, Arkansas, Conway.

furrow of the chelicerae with three unequal teeth, middle tooth the largest and closer to the lateral, which is the smallest, than to the median.

The median apophysis of the palpus of *P. sylvanus* somewhat resembles that of *P. apacheanus*, both in shape and in having a light-colored tip. The palpus of *P. sylvanus* is distinguished by the presence of a straight-edged shelf-like structure proximad of the base of the median apophysis (Fig. 235).

Legs 4123, femora faintly banded. Tibiae I with eight ventral and lateral spines, the four proximal spines long, overlapping and ventral in position; the distal pair is apical in position. Tibiae II with eight ventral and lateral spines; the ventral prolateral spines are reduced almost to bristles; the distal pair of spines are apical in position.

Description of female.—From Cove Creek, Washington Co., Arkansas, V-10-61, No. L-70. Carapace 2.60 mm long, 1.80 mm wide, with a distinct submarginal light band, and tuning-fork pattern. Dorsum heavily pigmented, with a narrow light hastate mark and four pairs of spots covered with white scales. Ventral surface yellowish amber except for scattered pigment in the center of the venter and narrow streaks of pigment along the edge of the sternum. Anterior eye row narrower than the median row, slightly procurved; anterior median eyes twice as large as laterals, somewhat closer to laterals than to each other. Clypeus height equals a diameter of an anterior median eye. Lower margin of the furrow of the chelicerae with three almost equally spaced teeth, the middle tooth the largest, the other two almost equal in size.

The epigynum of *P. sylvanus* is unlike that of any other *Pirata* that we have examined (Fig. 236-237). Legs 4123, very faintly pigmented; the femora have a suggestion of annulations. Tibiae I with five long overlapping ventrolateral spines; distal apical spines not developed. Tibiae II with four ventral spines and one spine lateral in position, the proximal retrolateral spines longer than the prolaterals; distal spines not developed.

Variation.—*P. sylvanus* specimens are usually lightly pigmented. They may appear to have a marginal or submarginal light band on the carapace depending upon the amount of pigmentation; the same holds true for the legs. The femora may be lightly banded; we recorded one male with banded legs. The size appears to be nearly uniform, male carapaces averaging around 1.9 mm by 1.4 mm and the females 2.3 mm by 1.7 mm. Arkansas specimens may be smaller: males with carapace 1.7 mm long, females 1.5 mm long.

The median apophysis of the male palpus usually has a light colored tip, but this is not true for some heavily sclerotized specimens.

Distribution.—Southeastern United States. The records from Missouri, Tennessee, and Virginia are based on females and should be considered tentative until confirmed by the collection of males. The only record from Georgia is that from the types.

Specimens examined.—*Arkansas*: Bradley, Conway, Washington Counties; *Georgia*: 2 mi. E. Sylvania, Screven Co., Apr 17, 43, W 81° 35', N 32° 43', W.I., male holotype, female allotype (A.M.N.H.); *Louisiana*: Hamburg, W.M.B., V-63, 4 males, 29-IV-63, 6 males, female; *Missouri*: Rolla, Phelps Co., X-48, H.E.F., female (H.E.); *North Carolina*: Weaverville, Buncombe Co., V-26-34, H.K.W. 332, male, female (H.K.W.); *Tennessee*: Kingston, Roane Co., 7-12-33, W.I., 16 females (Utah); *Virginia*: Amissville, Rappahannock Co., 8-18-39, R.V.C., female (Utah).

Life history.—Males have been collected from April into September and females from April into October. The only egg sac we have examined from a dated collection is from October.

Ecology.—Most of the specimens we have examined are from pitfall traps and most of those are from Arkansas: from traps in cotton, sorgham and alfalfa fields and in pastures. It also has been collected under stones near ponds and creeks.

Remarks.—*P. sylvanus* is larger than *P. apalacheus*; their palps are somewhat similar, but their epigyna are quite different. The anterior eye row in *P. apalacheus* is distinctly procurved while in *P. sylvanus* it is straight or only slightly procurved. The epigyna of *P. alachuus* and *P. sylvanus*, resemble each other superficially, but in the former there are openings on the ventral surface of the lobes of the epigynum (Figs. 8, 173-174), while in the latter the openings are on the posteromedial edge of the lobes (Figs. 12, 237).

ABBREVIATIONS

A.E., anterior eyes; A.L.E., anterior lateral eyes; A.M.C., A. M. Chickering; A.M.E., anterior median eyes; A.M.N.H., American Museum of Natural History; A.R.E., anterior row of eyes; B.J.K., B. J. Kaston; B.M.N.H., British Museum (Natural History); C.A.S., California Academy of Sciences; C.D.D., C. D. Dondale; C.G., Clarence Goodnight; D., diameter; D.C.L., Donald C. Lowrie; D.E.B., David E. Bixler; D.J.B., D. J. Buckle; D.P.I., Division of Plant Industry, University of Florida, Gainesville; E.S.G.R., E. S. George Reserve, Pickney, Michigan; H.E., Harriett Exline; H.E.F., Harriett Exline Frizell; H.G.P., Hillary G. Parrish; H.K.W., H. K. Wallace; J.A.B., J. A. Beatty; J.E.C., J. E. Carico; J.H.E., J. H. Emerton; K.P., Kenneth Prestwich; M.C.Z., Museum of Comparative Zoology; O.S.U., Oklahoma State University; P.L.E., posterior lateral eyes; P.M.E., posterior median eyes; P.M.R., posterior median row of eyes; P.R.E., posterior row of eyes; R.E.L., Robin E. Leech; R.I.B.O., Research Institute, Belleville, Ontario; R.O.M.Z., Royal Ontario Museum of Zoology; R.V.C., R. V. Chamberlin; S.C.B., Sherman C. Bishop; T.F.L., T. F. Hlavac; T.H.H., Theodore H. Hubbell; T.R.R., T. R. Renault; U.C.R., University of Costa Rica; U.F., University of Florida; U.F.C.R., University of Florida Conservation Reserve, Welaka; Utah, R. V. Chamberlin collection, now in the A.M.N.H.; W.B.P., William B. Peck; W.I., Wilton Ivie; W.J.G., Willis J. Gertsch; W.M.B., William Morton Barrows.

ACKNOWLEDGEMENTS

The authors are indebted to a large number of people and institutions who helped in many ways in the preparation of this paper: to Mr. Paul Laessle, Staff Artist, who is responsible for mounting and numbering the photographs and drawing the illustrations for the keys; to Mrs. Ruth Smith, Chief Clerk, who has always gone out of her way to provide material for the study; to the departmental secretaries for helping type the manuscript; to Dr. John Anderson and Dr. Jonathan Reiskind for help and consultation with spider problems and reading and criticising the keys and manuscript; to Dr. Charles Harper for companionship and help on collecting trips; to Dr. Willis J. Gertsch, Dr. Herbert Levi, and Dr. B. J. Kaston for the loan of specimens and consultation over a span of more than twenty years; to Dr. I. J. Cantrall for help in collecting and many favors while Wallace was in residence on the E. S. George Reserve of the University of Michigan; to the Mountain Lake Biological Station for providing funds, food and lodging for the Wallaces during four summers; to the following individuals and institutions for lending

specimens or helping in other ways: Paul H. Arnaud, Jr., California Academy of Sciences; David Barr, Royal Ontario Museum; Joseph A. Beatty, Southern Illinois University; J. W. Butler, Butler University; David E. Bixler, Chaffey College; Allen R. Brady, Hope College; Donald J. Buckle, Preeceville, Saskatchewan; George W. Byers, University of Kansas; James E. Carico, Lynchburg College; A. M. Chickering, M.C.Z.; John A. L. Cooke, A.M.N.H.; W. A. Drew, Oklahoma State University; C. D. Dondale, Agriculture Canada, Ottawa; Frank Enders, North Carolina Department of Public Health; George F. Edmunds, Jr., University of Utah; W. Don Fronk, Colorado State University; F. William Howard, Louisiana State University; K. H. Hyatt, British Museum of Natural History; John L. Kaspar, Wisconsin State University, Oshkosh; Robin E. Leech, Entomological Research Institute, Ottawa; Donald C. Lowrie, Santa Fe, New Mexico; Martin H. Muma, Silver City, New Mexico; William B. Peck, Central Missouri State College; Norman Platnick, A.M.N.H.; Kenneth Prestwich, University of Florida; Vincent D. Roth, Southwestern Research Station, Portal, Arizona; Jerome S. Rovner, Ohio University, Athens; Richard J. Sauer, Michigan State University; Beatrice Vogel, Billings, Montana; Howard Weems, D.P.I., University of Florida; Glenn Wiggins, Royal Ontario Museum, Toronto.

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VOLUME 5

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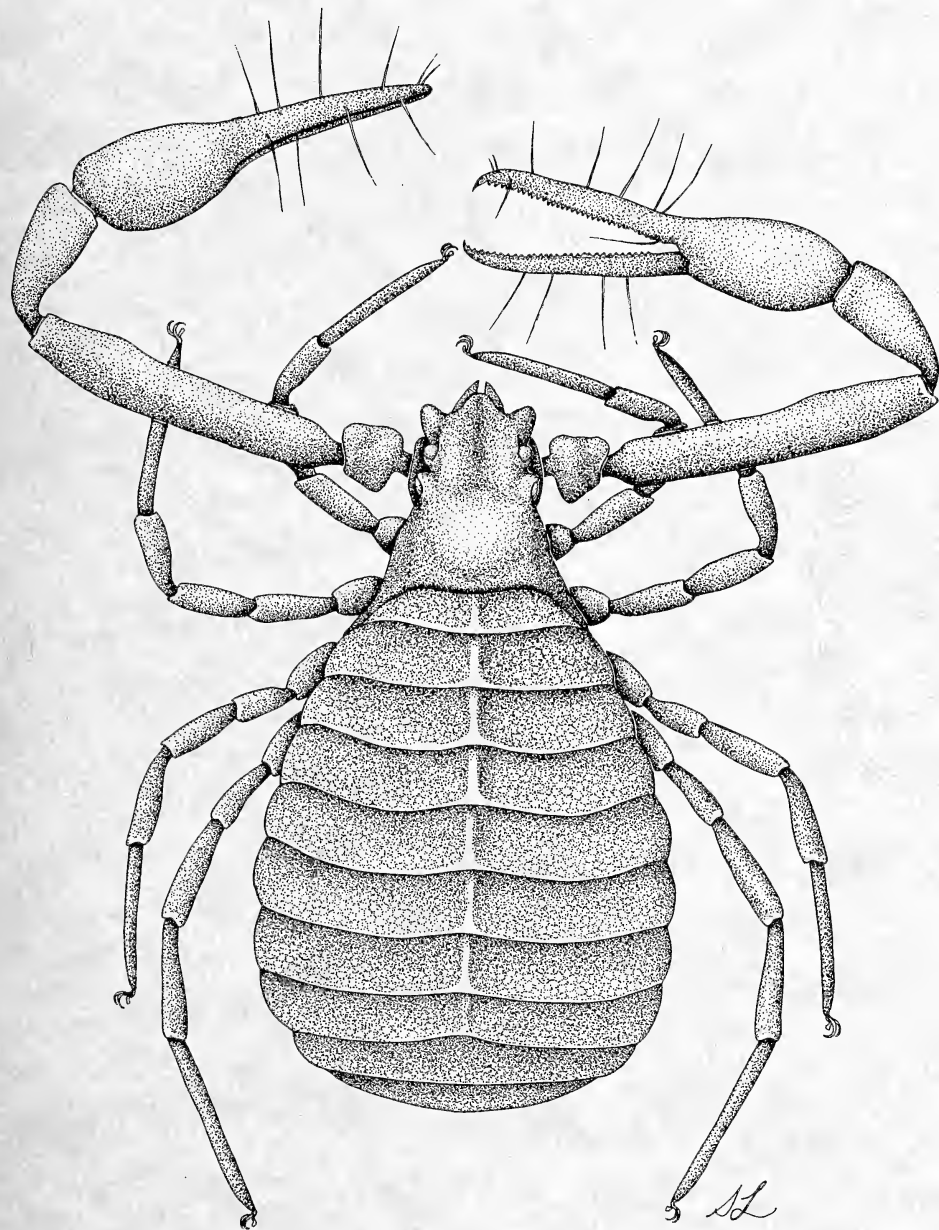
Printed by the Speleo Press, Austin, Texas

Posted at Warrensburg, Missouri, U.S.A., February, 1978

658
Ent.

The Journal of ARACHNOLOGY

OFFICIAL ORGAN OF THE AMERICAN ARACHNOLOGICAL SOCIETY



VOLUME 5

SPRING 1977

NUMBER 2

23

THE JOURNAL OF ARACHNOLOGY

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Individual subscriptions, which include membership in the Society, are \$12.50 for regular members, \$7.50 for student members. Institutional subscriptions to *The Journal* are \$15.00. Correspondence concerning subscription and membership should be addressed to the Membership Secretary. Back issues of *The Journal* are available from the Secretary at \$5.00 for each number. Remittances should be made payable to *The American Arachnological Society*.

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SOME GARYPOID FALSE SCORPIONS FROM WESTERN NORTH AMERICA (PSEUDOSCORPIONIDA: GARYPIDAE AND OLPIIDAE)

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ABSTRACT

A new genus and species, *Oreolpium nymphetum*, and a new species, *Larca chamberlini* are described. *Olpium frontalis* Banks and *Pseudogarypinus marianae* (Chamberlin) are synonymized and redescribed. Distributional data is provided for the above species and *Archeolarca rotunda* Hoff and Clawson.

INTRODUCTION

This paper, one of a series resulting from studies originally centered upon pseudoscorpions collected in Oregon, reports on the four western garypoid species currently known to occur in the state. It includes several new records from various localities in the western United States, the description of a new genus and two new species, and a clarification of the relationship between *Olpium frontalis* Banks and *Pseudogarypinus marianae* (Chamberlin). This latter problem has been an area of confusion in the literature for a number of years.

For some time, we have found in making measurements of various structures that it is often nearly impossible to secure reliable measurements of the chela when it remains attached to the palp. Therefore, we have modified the system of reference lines and points as used by Chamberlin (1931) by taking the measurements from the lateral aspect of the detached chela as illustrated in Figure 1.

FAMILY GARYPIDAE

Hansen, 1894, p. 231 (erected family). Chamberlin, 1931, pp. 226-228 (revised diagnosis with six included genera). Hoff, 1956, p. 44 and 1964, pp. 39-40 (revised diagnosis).

Garypids, represented by about 20 genera from both hemispheres, are considered to be mostly tropical and subtropical in distribution (Hoff, 1964). In the United States, five species assigned to three genera have been reported: *Garypus floridensis* Banks from Florida, and *G. californicus* Banks from California; *Larca granulata* (Banks) from the central and eastern states, and *L. notha* Hoff from Colorado; and *Archeolarca rotunda* Hoff and Clawson from New Mexico and Utah.

Heretofore, garypids have not been reported in the literature from the Pacific Northwest although the specimens of *Larca* upon which the new species is based have been in the J. C. Chamberlin Collection since their recovery in Oregon in 1941 and in California in 1955. Our recent field work in central Oregon has further revealed a single specimen of *Archeolarca rotunda*.

As early as 1949, Hoff recognized the family Garypidae as belonging to the suborder Diplosphyronida. Later (1964), he delimited the family by the following characters: both fingers of chela with venom apparatus and tooth; pleural membrane not evenly and smoothly plicate; carapace triangular or subtriangular in shape; coxal area, in most species, wider posteriorly than anteriorly; investing setae of palps and tergites relatively short and inconspicuous. Both of the genera from Oregon belong to the Garypinae, one of the two subfamilies currently recognized.

Genus *Larca* Chamberlin

Larca Chamberlin, 1930, p. 609, p. 616 (original diagnosis; *Garypus latus* Hansen designated as generotype). Beier, 1932, p. 224 (key to two species). Hoff, 1949, p. 447 (expanded diagnosis); 1961, p. 435 (amended diagnosis).

The holarctic genus *Larca*, which includes fewer than ten species, was established by Chamberlin in 1930 for *Garypus latus* Hansen 1884 from Denmark and for *Garypus granulatus* Banks 1891 from New York. A second North American species, *L. notha*, from Colorado, was added in 1961 by Hoff. This paper describes a third North American species from Oregon and California.

Pseudoscorpions of this genus are characterized (Hoff, 1961) by: movable chelal finger of adult with only *two* or *three* tactile setae; some arcuate and lanceolate palpal vestitural setae; tactile seta ET of fixed chelal finger near mid-point, other setae proximal; pedal

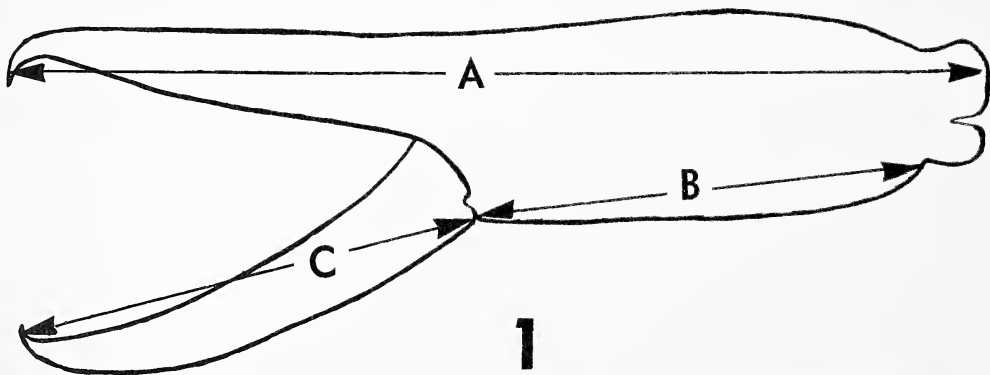


Fig. 1.—Reference lines and key points used to measure chelae: A, chelal length including pedicel; B, hand length; and C, movable finger length.

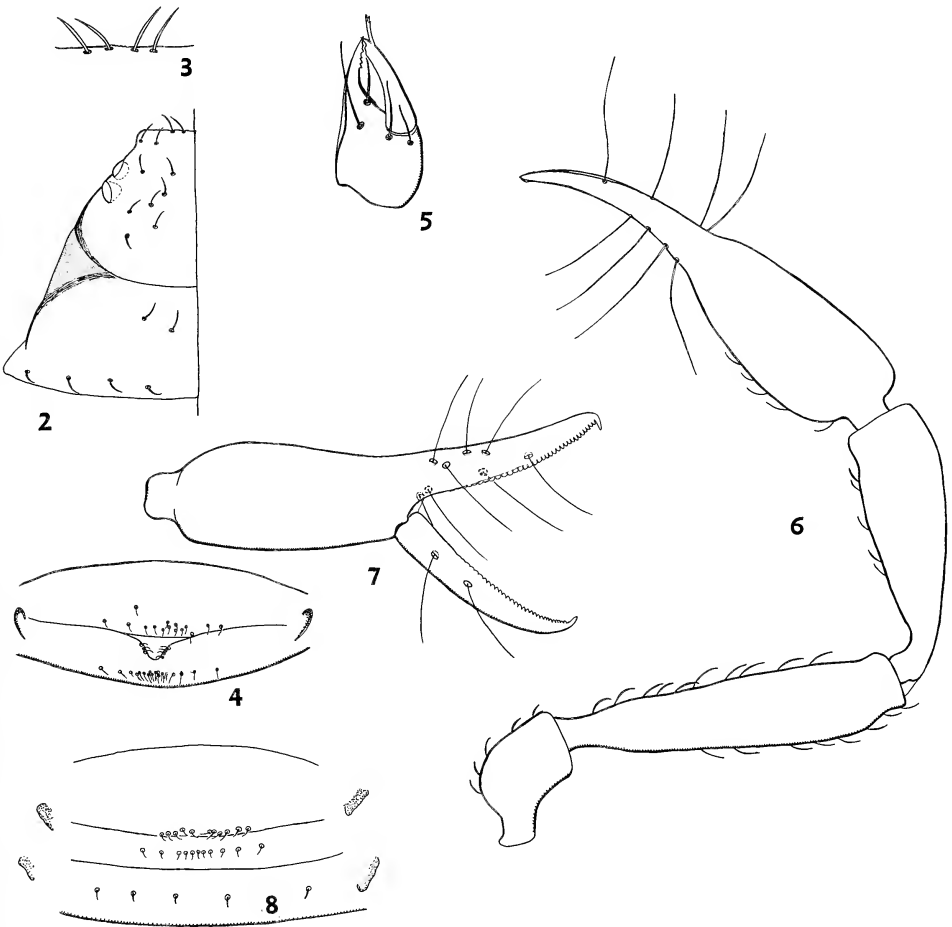
tarsi divided; pars basalis of leg I longer than pars tibialis; arolium longer than tarsal claws. The flagellum is described by Hoff as consisting of four blades, but since specimens from Oregon appear to have three blades, this character may not be constant in all species of *Larca*.

Larca chamberlini, new species
(Figs. 2 to 8)

Description.—Moderately-sized (male $1.82\text{--}1.92 \pm$ mm body length, female $1.84 \pm$ mm), four-eyed species; derm granulate to reticulate with more or less arcuate setae.

Male.—Measurements in Table 1.

Carapace (Fig. 2): one and one-half times longer than ocular breadth; subtriangular, with truncate anterior margin. Lacking distinct epistomal process but with weak dentations between two medial setae (Fig. 3); derm granulate; two pairs strongly corneate eyes,



Figs. 2 - 8.—*Larca chamberlini* n. sp., drawn from the holotype male (JC-1696.01001) except as indicated: 2, carapace; 3, epistomal area; 4, genital operculum of male; 5, chelicera; 6, dorsal aspect of palp of male; 7, external aspect of chela of male showing details of chelal teeth; 8, genital operculum of allotype female (JC-1696.01002).

Table 1.—Measurements (in millimeters) of type specimens of *Larca chamberlini*, new species

Morphological Part ^a	Male		Female
	Holotype	Paratype	
Body L	1.92±	1.82±	1.84±
Abdominal B	1.18±	1.18±	1.13±
Carapace L	0.53	0.53±	0.49
Ocular B	0.32	0.31±	0.32
Posterior B	indeterm.	indeterm.	0.61±
Ant. eye diam.	0.043	0.051	0.047
Post. eye diam.	0.043	0.047	0.055
Chelicera L/B	0.18/0.09	indeterm.	0.17/0.09
Pedipalp			
Trochanter L/B	0.29/0.14	0.25/0.13	0.29/0.14
Femur L/B	0.69/0.15	0.64/0.14	0.68/0.15
Tibia L/B	0.57/0.16	0.58/0.16	0.57/0.16
Chela (with pedicel) L	0.88	0.81	0.89
Chela B	0.22	0.21	0.23
Chela D	0.20	indeterm.	0.22
Hand L	0.43	indeterm.	0.41
Movable finger L	0.40	indeterm.	0.42
Leg I			
Basifemur L/D	0.22/0.08	0.21/0.08	0.24/0.08
Telofemur L/D	0.17/0.09	0.16/0.08	0.17/0.09
Tibia L/D	0.19/0.06	0.19/0.06	0.20/0.06
Metatarsus L/D	0.16/0.05	0.15/0.04	0.15/0.05
Telotarsus L/D	0.16±/0.04	0.14/0.03	0.14/0.04
Leg IV			
Entire femur L/D	0.49/0.13	0.45/0.12	0.48/0.13
Tibia L/D	0.34/0.08	0.31/0.07	0.34/0.08
Metatarsus L/D	0.19/0.05	0.18/0.05	0.19/0.05
Telotarsus L/D	0.19/0.04	0.19/0.04	0.19/0.04

^aAbbreviations: B, breadth; D, depth; L, length

anterior pair about one and one-half ocular diameters from anterior margin, and one-fourth ocular diameter from posterior pair; chaetotaxy 8-8(40). Coxal area typical; holotypic chaetotaxy 2-mm-1-10:0-1-7:0-2-6 or 7:0-1-7-6.

Abdomen: broadly oval; most scuta weakly divided; derm granulate to reticulate; pleural membrane strongly wrinkled; genital area typical (Fig. 4); chaetotaxy of holotypic abdominal terga 6:6:10:11:12:12:11:12:10:9:11:mm, of sterna 15:(0-0):(0)3-4/19(0):(0)5(0):9:9:8:8:8:6:4:mm.

Chelicera (Fig. 5): derm reticulate; galea moderately long and terminally trifid; serrula exterior with 17 blades, serrula interior blade number indeterminable; flagellum of three blades; fixed finger with two small denticles along inner margin of apical tooth followed proximally by four slightly larger acute teeth; movable finger with three very weakly developed denticles just proximal of apical tooth; hand with four setae.

Palp (Fig. 6): derm coarsely granulate except distal surfaces of palpal fingers; vestitural setae strongly to weakly arcuate; proportions (Table 2). Chelal chaetotaxy and dentition as illustrated (Fig. 7); movable finger with only *two* tactile setae, fixed finger with typical eight setae; fixed finger with a graded series of 33 teeth, proximally acute and barely cuspid, basally lower, truncate, and acuspid; movable finger with 33 similarly arranged teeth.

- 2a(1b). Cheliceral hand with *five* setae; from eastern United States *L. granulata* (Banks)

 2b. Cheliceral hand with *four* setae; from western United States
 *L. chamberlini*, n. sp.

From the data available, the species appears to be associated with mosquitoes. It has been collected: in CALIFORNIA, phoretically on a mosquito; and in OREGON in storage areas in an old house and an old shed associated with "roosting mosquitoes."

Type Records.—All specimens are mounted in Canada balsam. The holotype is deposited in the American Museum of Natural History; other types remain in the authors' collection.

Oregon. Benton County, 4 miles northeast of Corvallis, 28 October 1942, holotype male (JC-1696.01001) collected by R. Rosenstiel; 5 miles northeast of Corvallis, 6 November 1942, allotype female (JC-1696.01002) collected by R. Rosenstiel.

California. Yuba County, Camp Beale, 23 November 1945, one paratype male (JC-2040.01001) collected by S. E. Crumb.

This new species is named in honor of the late Joseph C. Chamberlin, who pioneered the modern study of pseudoscorpions.

Genus *Archeolarca* Hoff and Clawson

Archeolarca Hoff and Clawson, 1952, pp. 2-3 (original diagnosis; *Archeolarca rotunda* Hoff and Clawson designated as generotype). Hoff, 1956, p. 44 (expanded description).

The nearctic genus *Archeolarca* contains only the type species *Archeolarca rotunda* which Hoff and Clawson described in 1952 from material collected from rodent nests in Utah.

Pseudoscorpions of this genus are characterized (Hoff and Clawson, 1952; Hoff, 1956) by: the widely ovate abdomen; palpi slender with bent and sublanceolate vestitural setae; movable chelal finger of adult with *four* tactile setae, T and ST submedial, and SB and B proximal; fixed chelal finger with eight tactile setae, IST a little proximal to medially positioned EST and IT and only slightly closer to IT than to ISB; laminal seta of chelicera lacking; pars basalis of leg I conspicuously longer than pars tibialis; arolium longer than tarsal claws; flagellum with four blades.

Archeolarca rotunda Hoff and Clawson

Archeolarca rotunda Hoff and Clawson, 1952, pp. 3-8 (original diagnosis). Hoff, 1956, pp. 44-46 (additional description and record).

Direct comparison of our specimen from central Oregon (EB.E-60.01001) with Hoff's holotype and allotype from Utah shows that all three are conspecific. Phase microscopy reveals that the derm of the palps should be described as *strongly* instead of "moderately" granular (Hoff, 1952, p. 4).

Distribution.—The known distribution of *Archeolarca rotunda* as determined from the literature and from the study of specimens by the authors is as follows: NEW MEXICO, Bernalillo County (Hoff, 1956). OREGON (new record), Deschutes County: Unnamed cave, Arnold Lava Cave System, 11 miles south, 10 miles east of Bend, 3 June 1972, one male (E. M. Benedict, collector). UTAH, Utah County (Hoff and Clawson, 1952).

A specimen (JC-1545.01001) collected at Fort Bridger, Wyoming, may be this species but it is in such poor condition that accurate determination is difficult. Further specimens are needed for study to verify that *Archeolarca rotunda* occurs in the state.

FAMILY OLPIIDAE

Chamberlin, 1930, p. 588 (erected family with 12 genera); 1931, pp. 223-226.

Olpiids are considered to have reached their greatest development in the arid tropics and subtropics throughout the world (Chamberlin, 1930). Although species of this family have been reported from North Carolina, Florida, Texas, New Mexico, Utah, Colorado, and California, extensive collections from other parts of the United States have failed to contain olpiid pseudoscorpions. Therefore, it is particularly interesting that recent field searches in the Pacific Northwest have revealed the presence of two olpiid species in certain more xeric habitats: *Olpium frontalis* Banks [= *Pseudogarypinus frontalis* (Banks)] from Oregon and Washington and *Oreolpium nymphum*, a new genus and species from Oregon.

These two species clearly show the characteristics of the family as specified by Chamberlin (1930, 1931): diplotarsate legs; nearly parallel-sided carapace, coxal area and abdomen; venom apparatus in both chelal fingers; smooth evenly-plicate pleural membrane; long slender palpal and tergal setae; and arolium distinctly longer than tarsal claws.

Systematic work with the Olpiidae is frequently difficult and confusing. This family, subdivided into two subfamilies, includes about 20 genera in the Olpiinae, and about 10 genera in the Garypininae. Many of the diagnoses at the generic as well as at the specific level need revision before species can be identified with any degree of confidence and before accurate subfamilial relationships determined. The two species, herein discussed, clearly illustrate the problem.

SUBFAMILY OLPIINAE

Banks, 1895, p. 2, p. 10 (erected subfamily under the Obisiidae). Chamberlin, 1930, p. 588, p. 598 (transferred to Olpiidae and characterized); 1931, p. 225. Hoff, 1945, p. 1 (revised diagnosis).

The new genus *Oreolpium* with one species is the only pseudoscorpion of the Olpiinae currently known from the Pacific Northwest. Chamberlin (1930) characterized the Olpiinae as exhibiting entire arolia, entire tergites and sternites, and flagella with three blades. Although Chamberlin initially restricted the diagnosis of the Olpiinae to include only genera with three flagellar blades, Beier later (1932) assigned genera with four blades, and Hoff (1945) added a genus with two blades. Thus, in this character, the Olpiinae overlap the Garypininae, which have been considered as four-bladed.

The new genus *Oreolpium* may be tentatively assigned to the Olpiinae since it exhibits the characteristic arolia, tergites, and sternites which are entire.

Oreolpium, new genus

Diagnosis.—With the characteristics of the family Olpiidae and the subfamily Olpiinae; chelicera with galea terminally trifid; subapical lobe of movable cheliceral finger weakly bilobate; serrula interior weakly developed; flagellum four-bladed; palpal femur with a single dorsal sensory seta near the middle; marginal teeth of both chelal fingers well-developed; venom ducts short with nodus ramosus of the fixed finger distal to seta ET; tactile setae T, ST, SB, and B nearly equally spaced and all proximal to the midpoint of the movable chelal finger; ET on the distal one-third of the fixed finger, the other seven setae on the proximal half; IB on the dorsal surface of the hand just proximal to the finger base; ISB and IST paired and about one-third closer to IT than to IB; EB and ESB closely paired and closer to IB than to ISB and IST; scuta of abdomen entire; femur pars tibialis and pars basalis of leg I subequal in length; femur of leg IV at least two and one-half times longer than deep; arolia entire.

Generotype.—*Oreolpium nymphum*, new genus and new species.

Remarks.—The numerous inadequate descriptions of many species now assigned to the Olpiinae make it difficult to assess the relationships of the genus *Oreolpium* to related genera. The new genus is characterized by the subequal lengths of the basifemur (=pars basalis) and telofemur (=pars tibialis) of leg I; by the very short length of the poison ducts and the extremely distal position in each chelal finger of the nodus ramosus. These characters according to Hoff (1945, 1964) are typical of the tribe Xenolpiini. However, since the poison apparatus is so difficult to see in extremely diminutive or poorly cleared specimens and since the location of this structure is unreported in the literature for so many of the species, it seems desirable to withhold definitive tribal assignment of this new genus until a thorough study is made to determine if the above combination of characters actually reflects tribal relationships.

Our study of the few available illustrations in the literature and examination of type specimens of representative species of several genera shows that the new genus *Oreolpium* can be readily distinguished from similar genera by the unique chaetotaxy of the chelal movable finger. Setae T, ST, SB, and B are equally spaced and all are proximal to the median point of the finger. In *Austrohorus* Beier, *Pseudohorus* Beier, *Minniza* Simon, *Novohorus* Hoff, and *Horus* Chamberlin, seta T is located between the distal half and distal one-third of the finger. Geographically, the nearest relatives of the new genus are species of *Novorhorus* from the West Indies and Florida. In *Novohorus* seta IT of the fixed finger of the chela is distal to EST and in *Oreolpium* IT is proximal.

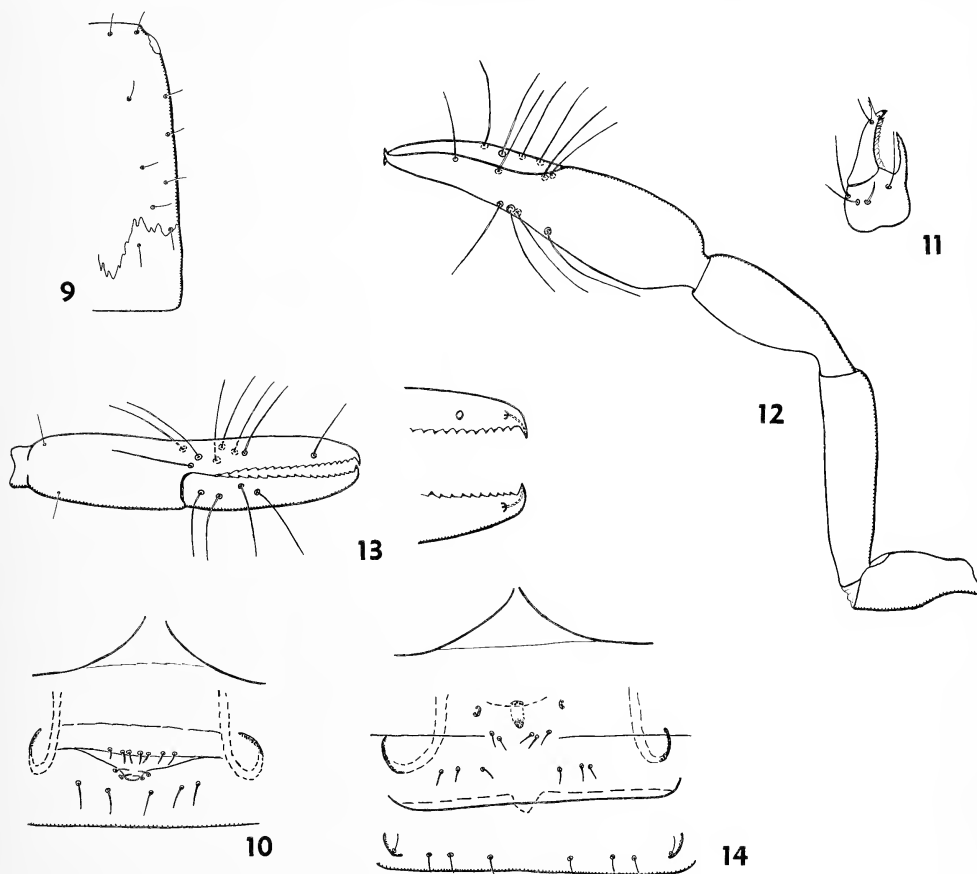
Oreolpium nymphum, new species
(Figs. 9 to 14)

Description.—Relatively small (male 1.87-2.00 mm body length, female 2.19-2.33 mm), two-eyed epigean species; derm mostly smooth with slender delicate setae. Measurements in Table 3.

Male.—Carapace (Fig. 9): at least twice as long as ocular breadth; derm smooth and only partially sclerotized, membranous posteriorly and laterally; epistomal process lacking; two weakly corneate eyes located about one ocular diameter from anterior carapacial margin; chaetotaxy somewhat irregular in number and arrangement but generally 4-4(20). Coxal area typical but with somewhat irregularly arranged setae, chaetotaxy typically 3-5 or 6-3:0-4-2:4-2:2-2:1-2 or 3.

Abdomen: long and slender; scuta entire; derm of anterior sternites faintly reticulate; anterior and posterior marginal areas of tergites and sternites lacking pigment and weakly sclerotic; pleural membrane smoothly plicate; genital area (Fig. 10); chaetotaxy of terga 6:4 to 6:4 to 6:5 to 6:6:6:6:6:6:10:10:2, of sterna 7 to 8:(0-0):(0) 2-2-5 to 6(0):(2)5 or 6(2):6:6:6:6:6:10:6:2.

Chelicera (Fig. 11): derm smooth except for weakly developed reticulations at base of fixed finger; galea relatively long and terminally trifid; lamina exterior lacking; serrula exterior with 14 blades; serrula interior a weakly developed membranous velum; flagellum of four blades; apical teeth of fingers no more strongly sclerotic nor deeply pigmented than rest of fingers, apical tooth of fixed finger with three denticles along inner margin



Figs. 9 - 14.—*Oreolpium nympha* n. sp., drawn from the holotype male (EB-1503.01002) except as indicated: 9, carapace showing posterior margin of sclerotization; 10, genital operculum of male; 11, chelicera; 12, dorsal aspect of palp of male; 13, external aspect of chela of male showing details of chelal teeth and nodus ramosus (terminal tooth of fixed finger reconstructed); 14, genital operculum of allotype female (EB-1503.01001).

Table 3.—Measurements (in millimeters) of type specimens of *Oreolpium nympha*, new species

Morphological Part ^a	Males	Females	Tritonymph	Protonymphs
Body L	1.87-2.00	2.19-2.33	1.92±	1.32±-1.42±
Abdominal B	0.38-0.46±	0.44-0.51	0.33±	0.26
Carapace				
L	0.48-0.51	0.65-0.69	0.45	0.36
Ocular B	0.22-0.23	0.21-0.27	indeterm.	0.22±-0.27±
Posterior B	0.28-0.32	0.32-0.39	0.27±	0.27±-0.30±
Eye diameter	0.02-0.03	0.03-0.04	0.025	indeterm.
Chelicera L/B	0.12/0.07	0.12-0.14/0.07	indeterm.	0.08/0.06
Pedipalp				
Trochanter L/B	0.20-0.21/0.09-0.10	0.22-0.23/0.09-0.10	indeterm.	0.11-0.12/0.07
Femur L/B	0.33-0.35/0.08-0.09	0.33-0.39/0.10-0.11	0.26/0.09	0.17/0.06-0.07
Tibia L/B	0.30-0.31/0.10-0.11	0.32-0.35/0.11-0.12	0.24/0.10	0.15-0.16/0.07
Chela (with pedicel) L	0.56-0.59	0.62-0.63	0.48	0.33
Chela B	0.13-0.15±	0.15±	0.12	0.08-0.09
Chela D	0.11	0.13-0.14	0.11	0.08-0.09
Hand L	0.25-0.26	0.29	0.23	0.16
Movable finger L	0.30	0.30	0.23	0.17
Leg I				
Basifemur L/D	0.10/0.07	0.11±/0.07-0.08	indeterm.	0.06/0.04
Telofemur L/D	0.11-0.13/0.06-0.07	0.11-0.12/0.07-0.08	indeterm.	0.06/0.04
Tibia L/D	0.14-0.16/0.04-0.05	0.15-0.16/0.05	indeterm.	0.08/0.04
Metatarsus L/D	0.06-0.04	0.06-0.07/0.03-0.04	indeterm.	0.04/0.03
Telotarsus L/D	0.08-0.09/0.02-0.03	0.06-0.08/0.03-0.04	indeterm.	0.04/0.03
Leg IV				
Entire femur L/D	0.36-0.38/0.09-0.10	0.34-0.35/0.10-0.11	0.18/0.08	0.17/0.06
Tibia L/D	0.22-0.23/0.06-0.07	0.22-0.24/0.07-0.08	0.15/0.06	0.11/0.05
Metatarsus L/D	0.08/0.04	0.08-0.09/0.04-0.05	0.05/0.04	0.06/0.04
Telotarsus L/D	0.09-0.10/0.04	0.10-0.11/0.04	0.05/0.03	0.05/0.03

^aAbbreviations: B, breadth; D, depth; L, length

Table 4.—Appendicular morphometric ratios of type specimens of *Oreolpium nymphi*, new species

Appendage ^a	Males	Females	Tritonymph	Protonymph
Pedipalp				
Trochanter L/B	2.1-2.3	2.3	indeterm.	1.6-1.7
Femur L/B	3.6-4.0	3.4-3.9	2.9	2.5-2.6
Tibia L/B	2.6-2.7	2.6-3.0	2.4	2.0-2.3
Chela (with pedicel) L/B	4.4	4.0-4.1	4.1	3.8-4.0
Chela (with pedicel) L/D	5.2	4.5-4.8	4.5	3.8-4.0
Movable finger L/Hand L	1.2	1.1	1.0	1.03-1.09
Hand L/D	1.6	2.1	2.1	1.8-1.9
Leg I				
Basifemur L/D	1.4	1.3-1.6	indeterm.	1.3
Telofemur	1.6-1.7	1.4-1.7	indeterm.	1.3
Tibia L/D	2.8-2.9	2.8-3.0	indeterm.	2.0
Metatarsus L/D	1.6	1.6-1.9	indeterm.	1.3
Telotarsus L/D	2.2-2.6	2.0-2.3	indeterm.	1.5
Leg IV				
Entire femur L/D	3.4-3.5	3.2-3.4	2.6	2.9
Tibia L/D	3.4-3.5	2.9-3.4	2.5	1.8
Metatarsus L/D	1.8	1.7-2.0	1.1	1.5
Telotarsus L/D	2.3-2.5	2.5-2.9	1.6	1.4

^aAbbreviations: B, breadth; D, depth, L, length

succeeded by three retrorse teeth basally; apical tooth of movable finger weakly bifid, subapical lobe small and bilobate; hand with five setae.

Palp (Fig. 12): vestitural setae slender and delicate; proportions (Table 4). Chela chaetotaxy and dentition as illustrated (Fig. 13); fixed finger with 18 spaced, retrorse teeth, becoming lower basally, movable finger with 18 similarly arranged but slightly less developed teeth basally.

Legs: short and stout; proportions (Table 4); basifemur and telofemur of leg I of equal length; leg IV with long tactile seta on tibia and metatarsus.

Female.—Similar to male except as noted. Genital area typical (Fig. 14), lateral cribri-form plates of allotype 0.012 by 0.007 mm, anterior median plate 0.015 wide, posterior median plate 0.009 by 0.009 mm; chaetotaxy of allotypic abdominal terga 5:5:4:5:6:6:6:6:8:8:mm, of allotypic sterna 5:(0)6(0):(1)6(1):6:6:6:6:6:8:10:mm. Fixed finger of chela with 17 to 20 teeth and movable with 16 to 19 teeth. Palpal and leg proportions (Table 4).

Tritonymph.—(Based on EB-1558.02002). Similar to adult except as noted. Paler and smaller; carapacial chaetotaxy 4-2(18); abdominal chaetotaxy typical but indeterminable. Chelicera closely resembles adult with teeth of both fingers and chaetotaxy typical. Chelal movable finger with three tactile setae, fixed finger with seven setae; fingers each with 14 teeth. Palpal and leg proportions (Table 4).

Deutonymph.—Not represented in the collections.

Protonymph.—(Based on EB-1558.02001 and EB-1634.01001). Similar to adult except as noted. Much smaller; derm is less well-sclerotized, paler. Carapacial chaetotaxy

4-2(14); eyes much less developed, barely corneate. Chaetotaxy of terga 2:2:2:2:4:4:4:4:?:2:2, of sterna 0:(0)0(0):(1)0(1):4:4:4:4:5 or 6:?:4:2. Coxal chaetotaxy 3-1-1:1-0-0:0-0-1:0-0-1:0-0-1. Chelicera less developed, derm smooth, serrula exterior with about 10 blades; hand with four setae. Chelal movable finger with one tactile seta, fixed finger with three tactile setae, fingers each with 11 teeth. Palpal and leg proportions (Table 4).

Remarks.—The new species is based upon unusual adults of a slender nymph-like form which were extracted from Berlese samples of old mature bark taken from western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), and sugar pine (*Pinus lambertiana*) trees located in forests at elevations of 1,000 to 6,000 feet in western Oregon. Due to their tiny size and delicate structure, these specimens, which are lightly pigmented and weakly sclerotized, appear immature. However, under adequate magnification typical genitalia have been discerned. The biparte nature of the subapical lobe of the movable cheliceral finger is difficult to see except under the very best conditions due to their exceedingly small size. The new species can be discriminated, even under low magnification, from other Oregon species of a similar size and shape by the very distinctive pattern of sclerotization of the posterior half of the carapace (Fig. 9).

Type Record.—Oregon. Lane County, 4 miles north, 13 miles east of Lowell, 30 August 1973, male holotype (EB-1503.01002), female allotype (EB-1503.01001), one male (EB-1503.01003), and three female paratypes (EB-1503.01004, EB-1503.01005, EB-1506.01001). Additional paratypes as follows: Douglas County, 8 miles south, 4 miles east of Tiller, 13 September 1973, one female (EB-1558.02003), one tritonymph (EB-1558.02002) and one protonymph (EB-1558.02001); 14 September 1973, one male (EB-1566.01001). Jackson County, 6 miles south, 12 miles west of Ashland, 17 September 1972, one female (EB-864.01001); 8 miles south, 13 miles east of Ashland, 15 October 1972, one male (EB-951.01001) and one female (EB-951.01002). Linn County, 12 miles north, 28 miles east of Sweet Home, 17 September 1973, one male (EB-1621.02002) and one female (EB-1621.02001). Marion County, 5 miles due north of Mill City, 17 September 1973, one female (EB-1634.01002) and one protonymph (EB-1634.01001). All specimens collected by E. M. Benedict and mounted in modified Hoyer's Berlese medium. Holotype and allotype deposited in American Museum of Natural History; paratypes are retained in the authors' collection.

SUBFAMILY GARYPININAE

Daday, 1887, p. 123, p. 179 (erected subfamily). Chamberlin, 1930, p. 588, p. 590 (transferred to Olpiidae and characterized); 1931, p. 225.

Pseudogarypinus frontalis (Banks), the only currently known species of the Garypininae from the Pacific Northwest, exhibits most of the characters of the subfamily as specified by Chamberlin (1930): bifurcate arolia, some divided tergites and sternites, and flagella each of four blades. As discussed under the Olpiinae, the number of blades on the flagellum may not be a good criterion for distinguishing the two subfamilies. Not only are there genera with four-bladed flagella assigned to each subfamily but there appears to

be variation within a single specimen (one specimen of *Pseudogarypinus frontalis* has four blades in one flagellum and six in the other). In addition, even when blade number is constant, it is frequently difficult to determine it accurately on poorly oriented specimens.

Genus *Pseudogarypinus* Beier

Pseudogarypinus Beier, 1931, p. 313 (original diagnosis; *Pseudogarypinus costaricensis* Beier designated as generotype); 1932, p. 206 (key to species). Hoff, 1956, p. 33 (expanded generic description).

The North American genus *Pseudogarypinus* was established by Beier in 1931 for his species *Pseudogarypinus costaricensis* from Costa Rica and for *Garypinus marianae* Chamberlin 1930 from central California and Utah. Hoff (1956) suggested that *Olpium frontalis*, which had been described by Banks in 1909 from New Mexico, also should be assigned to this genus (see following discussion of *P. frontalis*). In 1961, *P. giganteus*, a species from Colorado, was described by Hoff.

Pseudoscorpions of this genus exhibit the following characters (Hoff, 1956): femoral articulations of legs I and II partially mobile with pars tibialis of leg I distinctly shorter than pars basalis; fixed finger of chelicera with a lamina exterior; and tactile seta ISB of the fixed finger of the chela much closer to IB than to IST; teeth of the chelal fingers equally developed on both fingers.

Pseudogarypinus frontalis (Banks) (Figs. 15 to 18)

Olpium frontalis Banks, 1909, p. 307 (original diagnosis). Hoff, 1961, p. 439, p. 442 (compared with *Pseudogarypinus marianae* (Chamberlin)).

Serianus frontalis (Banks), Beier, 1932, p. 213 ("Unsichere Art").

Pseudogarypinus frontalis (Banks), Hoff, 1956, pp. 33-34 (new combination and suggested synonymy with *Pseudogarypinus marianae* (Chamberlin)).

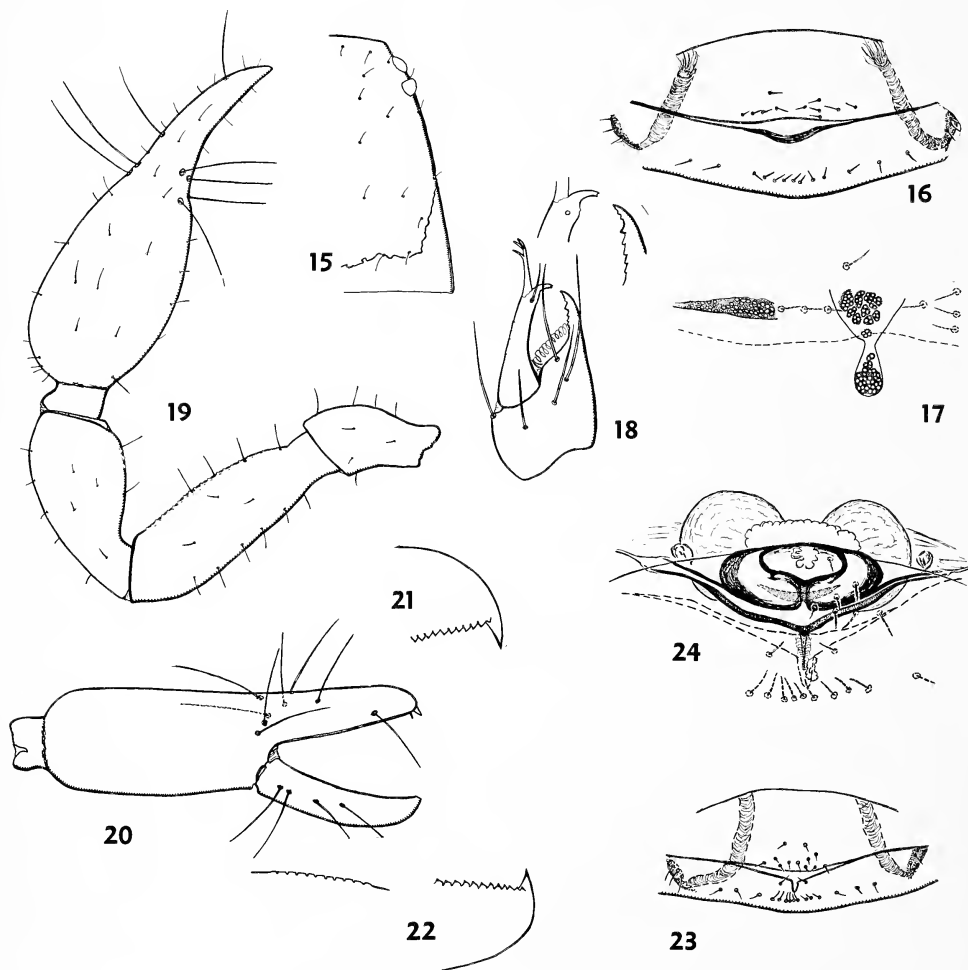
Pseudogarypinus ? frontalis (Banks), Hoff, 1958, p. 16; 1959, p. 4, p. 27.

Garypinus marianae Chamberlin, 1930, pp. 591-592 (original diagnosis).

Pseudogarypinus marianae (Chamberlin), Beier, 1931, p. 315 (new combination); 1932, pp. 206-207 (key). Hoff, 1958, p. 16 (suggested synonymy with *Olpium frontalis* Banks); 1961, pp. 439-440 (supplementary description based on records from Colorado).

The systematic affinities of the pseudoscorpion species *Olpium frontalis*, originally described by Banks from specimens collected at Las Vegas, New Mexico, have long been in question. Beier (1932) assigned the species to the genus *Serianus* under the category of "Unsichere Art." Hoff (1956) listed the species as "*Pseudogarypinus frontalis* Banks, new combination," but in the following discussion he appeared to qualify this conclusion by stating that "there is a *possibility* [emphasis added] that *Olpium frontalis* Banks, 1909, may belong to this genus" (p. 34). Hoff continued this equivocation in subsequent papers (1958, 1959) by listing the species with a question mark—"Pseudogarypinus ? frontalis (Banks).

Not only has the generic assignment of *Olpium frontalis* been somewhat in doubt, but its relationship to Chamberlin's species *Pseudogarypinus marianae* from California has also been puzzling. Hoff in 1956 noted from the original description of *O. frontalis* and *P. marianae* close agreement in their body size, shape of carapace, division of tergites, shape and sculpturing of the palpal femur, and relative lengths of the palpal hand and fingers. The only discrepancy seemed to be in the shape of the galea. Banks had described the galea of *O. frontalis* as "rather long, simple and with an out-turned tip" (1909, p. 307), whereas Chamberlin had described the same structure for *P. marianae* as "slender and with three terminal recurved branches" (1930, p. 592). Despite their very similar descriptions, Hoff (1956) declined to synonymize the two species until the exact relationships



Figs. 15 - 24.—*Pseudogarypinus frontalis* (Banks): 15, carapace showing posterior margin of sclerotization (JC-391.02002); 16, genital operculum of female (JC-391.02002); 17, internal structures of female genitalia, with external setae superimposed (JC-391.02002); 18, chelicera (JC-391.02003) with detail of cheliceral fingers; 19, dorsal aspect of palp of female (Banks' lectotype); 20, external aspect of chela of female (Banks' lectotype female)—all teeth missing; 21, details of distal teeth of chelal fixed finger (JC-391.02002); 22, details of distal teeth and most proximal teeth of movable finger (EB-864.02001); 23, genital operculum of male (JC-391.01001); 24, internal structures of male genitalia, with external setae superimposed (JC-391.01001).

between *frontalis* and *marianae* could be established by the restudy of the types of both species. Hoff in 1958 again suggested that the two were conspecific. Nevertheless, in 1961 he retained the name *P. marianae* for collections from Colorado even though he again discussed its possible synonymy with *O. frontalis*.

In order to correctly assign a name to several series of specimens from diverse localities which are clearly identifiable as *P. marianae*, when compared with Chamberlin's diagnosis and with the *P. marianae* type series, we have examined in detail the only available syntypes of *O. frontalis* (a female and a tritonymph). Although the female (mounted by Schuster) is in very poor condition, it, as well as the tritonymph, exhibits the typical structures of *Pseudogarypinus*. Thus, as surmised earlier by Hoff, the species *O. frontalis* is assignable to the genus.

Direct comparison of these syntypes with the type series of *P. marianae* shows that they are similar in all visible features, including the nature of the galea, which is trifid. Therefore, we conclude that *Pseudogarypinus frontalis* (Banks) and *Pseudogarypinus marianae* (Chamberlin) are synonymous.

Revised Description.—Moderate-sized (male 3.15 ± 3.89 mm body length, female 3.30 - 4.60 mm), four-eyed epigean species. Measurements in Table 5.

Female.—*Carapace* (Fig. 15): slightly longer than broad; derm weakly reticulate and only partially sclerotized, membranous posteriorly and laterally; epistomal process lacking; four moderately corneate eyes, anterior pair slightly more developed than posterior pair and located slightly less than one ocular diameter from anterior margin, interocular distance one-third to one-half ocular diameter; chaetotaxy generally 6-4(30). Coxal area typical, chaetotaxy 3-5-3 or 4:0-3 or 4-3:4-4:3-3:3-7.

Abdomen: relatively long and slender; tergite I entire, tergites II to V only faintly divided, tergites VI to X clearly divided, sternites II to X divided; derm weakly reticulate; anterior and posterior marginal areas of tergites and sternites lacking pigment and weakly sclerotized, pleural membrane smoothly plicate; genital area as illustrated (Figs. 16-17); lateral cribriform plate of lectotype 0.101 by 0.031 mm, posterior medial plate 0.020 by 0.019 mm, anterior medial plate 0.031 by 0.025 mm; range of variation of chaetotaxy given in Table 6, chaetotaxy of lectotypic terga 8:6:6:6:8:8:9:9:6:9:6:mm, of sterna 12 or 13:(3)12(3):(4)9(4):8:9:9:9:6:9:8:mm.

Chelicera (Fig. 18): galea relatively long and terminally trifid; lamina exterior a narrow marginal band; serrula exterior with about 20 blades; serrula interior membranous but distally divided into distinct blades; flagellum of four (rarely six) blades; hand with five setae; apical tooth of each finger sclerotized and pigmented to the same degree as rest of finger; apical tooth of fixed finger with three denticles along inner margin, succeeded by five retrorse marginal teeth diminishing in size basally; apical tooth of movable finger weakly bifid terminally, subapical lobe subdivided into three shallow denticles.

Palp (Fig. 19): derm mostly smooth except for weak to moderate granulations on the femur; vestitural setae of variable lengths, but mostly long and slender with several shorter setae on chelal fingers. Palpal proportions in Table 7. Chelal chaetotaxy and dentition as illustrated (Figs. 20-22); fixed finger with 41 to 50 teeth, distally acute and barely cuspid, basally becoming lower, truncate, and acuspid; movable finger with 33 to 49 similar but slightly more developed teeth.

Legs: relatively stout; proportions in Table 7; telofemur of leg I distinctly longer than basifemur; leg IV with a long tactile seta on metatarsus, and a somewhat shorter seta on tibia.

Table 5.—Measurements (in millimeters) of *Pseudogarypinus frontalis* (Banks)

Morphological Part ^a	Males	Females	Tritonymph	Deutonymph
Body L	3.15±-3.89	3.30-4.60	3.18±	2.56
Abdominal L	1.08±-1.33±	1.18-1.38	0.99±	0.70±
Carapace L	0.86-0.99	0.90-1.05	0.70	0.63
Ocular B	0.47±-0.58	0.50-0.68	0.42±	0.34±
Posterior B	0.70-0.79±	0.72-0.85	0.69±	0.39±
Ant. eye diam.	0.062-0.078	0.067-0.077	0.055	0.043
Post. eye diam.	0.054-0.074	0.056-0.068	0.030	0.037
Chelicera L/B	0.28-0.33/0.16-0.19	0.28-0.33/0.17-0.21	0.22/0.19	0.18/0.15
Pedipalp				
Trochanter L/B	0.38-0.47/0.22-0.27	0.41-0.48/0.23-0.29	0.32/0.16	0.27/0.16
Femur L/B	0.74-0.90/0.23-0.29	0.75-0.97/0.24-0.31	0.57/0.19	0.42/0.16
Tibia L/B	0.61-0.75/0.28-0.33	0.60-0.82/0.30-0.37	0.47/0.28	0.38/0.19
Chela (with pedicel) L	1.26-1.52	1.31-1.67	1.02	0.82
Chela B	0.36-0.44	0.39-0.50	0.31	indeterm.
Chela D	0.33-0.39	0.35-0.47	0.27	0.23
Hand L	0.64-0.80	0.70-0.89	0.50	0.39
Movable finger L	0.57-0.66	0.55-0.72	0.47±	0.37
Leg I				
Basifemur L/D	0.31-0.37/0.14-0.19	0.33-0.40/0.15-0.19	0.26/0.12	0.18/0.10
Telofemur L/D	0.22-0.28/0.14-0.17	0.23-0.30/0.16-0.19	0.12/0.13	0.08/0.10
Tibia L/D	0.32-0.39/0.09-0.12	0.33-0.41/0.11-0.13	0.16/0.09	0.20/0.07
Metatarsus L/D	0.13-0.16/0.07-0.08	0.14-0.17/0.07-0.08	0.10/0.07	0.08/0.06
Telotarsus L/D	0.17-0.23/0.06-0.08	0.17-0.21/0.07-0.09	0.15/0.06	0.13/0.05
Leg IV				
Entire femur L/D	0.73-0.88/0.25-0.32	0.78-0.96/0.24-0.33	0.60/0.20	0.49/0.19
Tibia L/D	0.51-0.60/0.15-0.20	0.53-0.66/0.16-0.20	0.41/0.13	0.32/0.12
Metatarsus L/D	0.17-0.22/0.09-0.11	0.18-0.23/0.09-0.11	0.14/0.08	0.12/0.07
Telotarsus L/D	0.22-0.28/0.07-0.10	0.23-0.29/0.08-0.10	0.19/0.07	0.15/0.06

^aAbbreviations: B, breadth; D, depth; L, length

Table 6.—Range of variation of abdominal chaetotaxy of *Pseudogarypinus frontalis* (Banks)

TERGITES					STERNITES				
Segment	Male	Female	Trito- nymph	Deuto- nymph	Male	Female	Trito- nymph	Deuto- nymph	
I	7 to 8	6 to 8	5	4	14 to 21	9 to 12	2	0	
II	6 to 10	6 to 10	4	4	(0-0)				
III	7 to 8	6 to 8	6	4	(3 or 4) 1 to 3-2 to 3(3 or 4)	(3) 11 to 13(3)	(2) 8(2)	(1) 4(1)	
IV	8	6 to 8	7	6	13 to 16		(2) 8(3)	(2) 6(2)	
V	8 to 10	8	7	6	(3 or 4) 7 to 11(3 or 4)	(4) 7 to 10(4)	7	6	
VI	7 to 10	8	6	6	9 to 11	8 to 9	8	6	
VII	8 to 10	8 to 9	6	6	9 to 10	9 to 10	8	6	
VIII	7 to 10	7 to 9	6	6	9 to 10	9 to 12	7	6	
IX	6 to 9	6 to 8	6	6	9 to 10	6 to 8	6	6	
X	8 to 12	9 to 12	8	6	7 to 10	9 to 12	8	6	
XI	8 to 10	8	8(?)	4	8 to 10	12	8	4	
XII	mm	mm	mm	mm	mm	mm	mm	mm	

Table 7.—Appendicular morphometric ratios of *Pseudogarypinus frontalis* (Banks)

Appendage ^a	Males	Females	Tritonymph	Deutonymph
Pedipalp				
Trochanter L/B	1.7-2.0	1.7-1.9	2.0	1.6
Femur	2.9-3.4	2.8-3.2	3.0	2.7
Tibia L/B	2.1-2.6	1.9-2.3	1.7	2.0
Chela (with pedicel) L/B	3.1-3.4	3.1-3.4	3.4	indeterm.
Chela (with pedicel) L/D	3.4-3.9	3.3-3.9	3.8	3.6
Movable finger L/Hand L	1.1-1.3	1.0-1.3	indeterm.	1.1
Hand L/D	1.8-2.0	1.7-2.0	1.9	1.7
Leg I				
Basifemur L/D	1.9-2.2	2.0-2.2	2.1	1.8
Telofemur L/D	1.4-1.7	1.4-1.7	1.8	1.8
Tibia L/D	3.0-3.6	3.0-3.4	2.8	2.7
Metatarsus L/D	1.6-2.1	1.8-1.9	1.4	1.4
Telotarsus L/D	2.5-3.1	2.4-2.8	2.3	2.4
Leg IV				
Entire femur L/D	2.5-3.0	2.7-3.3	2.9	2.6
Tibia L/D	2.9-3.5	3.1-3.6	3.2	2.7
Metatarsus L/D	1.7-2.3	1.8-2.2	1.7	1.7
Telotarsus L/D	2.6-3.2	2.5-3.1	2.6	2.5

^aAbbreviations: B, breadth; D, depth; L, length

Male.—Similar to female except as noted. Slightly smaller in general; range of abdominal chaetotaxy (Table 6); genital area as illustrated (Figs. 23-24). Palp slightly more slender; fixed finger of chela with 40 to 50 teeth and movable finger with 37 to 48 teeth; proportions in Table 7. Legs of typical structure (Chamberlin, 1930, Fig. 1T, 1AA); proportions in Table 7.

Tritonymph.—(Based on Banks' lectotype mounted by W. B. Muchmore). Similar to adult except as noted. Paler and smaller; carapacial chaetotaxy 4-4(26±); chaetotaxy of abdominal sterna and terga (Table 6). Chelicera closely resembles adult; tooth number of fixed finger indeterminable due to missing finger tip, but similar in form to adult. Chelal movable finger with three tactile setae, fixed finger with seven setae; fixed and movable fingers each with approximately 34 teeth. Palpal and leg proportions in Table 7.

Deutonymph.—(Based on JC-373.01001). Similar to adult except as noted. Much smaller; derm less well-sclerotized, paler. Carapacial chaetotaxy 4-4(22); eyes less well-developed, only slightly corneate. Chaetotaxy of abdominal sterna and terga (Table 6). Coxal chaetotaxy 3-3 or 4-2 or 3:2 or 3-2 or 3:2-2:2-1:2-1. Chelicera closely resembles adult unlike certain species in which the deutonymph exhibits immature chaetotaxy (Benedict & Malcolm, 1973). Chelal movable finger with two tactile setae; fixed finger with six setae; fixed finger with 30 teeth, movable finger with 25 teeth. Palpal and leg proportions in Table 7.

Protonymph.—Not represented in the collections.

Remarks.—This species shows a high degree of irregularity in the number of setae on the carapace, tergites, and sternites with the number frequently differing between the two

halves of the same sclerite. Only two species, *Pseudogarypinus frontalis* (Banks) and *P. giganteus* Hoff, are now assigned to this genus from the United States. While these two species still appear to be distinct, several differences which formerly were thought to exist have been invalidated by this study. Examination of syntypes and other specimens shows that, contrary to Hoff (1961), *P. giganteus* cannot be separated from *P. frontalis* by the nature of the galea, separation of the eyes, nor the distribution of granules on the palpal femur, since these characteristics are shared in common by both species. As a result, the only remaining distinguishing criteria are size and proportions. Since only one specimen of *P. giganteus* is known in the literature, it is impossible to predict the degree of intraspecific variation and thus the possible overlap of measurements and proportions with *P. frontalis*. At the present time, however, the following couplet will serve to separate the adults of the two species:

- 1a. Chelal length (without pedicel) of male 1.17-1.43 mm, of female 1.22-1.57 mm; palpal femur length of male 0.74-0.90 mm, of female 0.75-0.97 mm *P. frontalis* (Banks)
- 1b. Chelal length (without pedicel) of female 1.74 mm; palpal femur length of female 1.09-1.13 mm *P. giganteus* Hoff

Distribution.—The known distribution of *Pseudogarypinus frontalis* (including the synonymized species *P. marianae*) as determined from the literature and from the study of specimens by the authors is as follows: CALIFORNIA. Marin, Mariposa, San Mateo, and Santa Cruz Counties (Chamberlin, 1930). New records: Orange County: Laguna Beach, 28 December 1932, one female and one deutonymph (W. Ivie, collector). COLORADO. Larimer and Montezuma Counties (Hoff, 1961). NEW MEXICO. San Miguel County (Banks, 1909). OREGON. New records: Jackson County: 3 miles north of Copper, 13 November 1971, one female; 6 miles south, 12 miles west of Ashland, 17 September 1972, two females. Josephine County: 3 miles east of Selma, 10 August 1973, one female; 5 miles north of Galice, 14 September 1973, one male (all collected by E. M. Benedict). UTAH. Tooele and Washington Counties (Chamberlin, 1930). New records: Salt Lake County, 26 July 1932, one male (W. Ivie, collector); Mill Creek Canyon, 11-14 August 1941, six males and two females (J. C. Chamberlin, collector); Hughes Canyon, 20 May 1934, one deutonymph (W. Ivie, collector). WASHINGTON. New record: Klickitat County: 4 miles east of Mary Hill, 30 May 1941, three males and five females (J. C. Chamberlin, collector).

The disjunct distribution as presently known for *P. frontalis* probably reflects the lack of samples taken from suitable habitats rather than the actual nature of the species. Habitat data appear to indicate that the species is associated with bark or litter from relatively dry areas. It has been collected: in Utah, beneath stones in dry oak litter, in bark of dead cottonwood, and in maple and birch stumps; in Colorado, beneath stones and in litter of pinyon and yellow pines and juniper, and in litter of fir and aspen; in California, in dry litter, and in bark of madrone and sequoia; in Oregon, in litter of canyon live and California black oaks, and in Douglas fir bark; and in Washington, under bark of maple log.

Type Record.—New Mexico. San Miguel County, Las Vegas. Elevation approximately 6400 feet above sea level. Unknown number of syntypes, collected prior to 1909 by Cockerall, of which two are deposited in the Museum of Comparative Zoology: one

female [syntype of *Olpium frontalis* (Banks 1909, p. 307) = *Pseudogarypinus frontalis* (Hoff 1956, p. 33), hereby designated as lectotype] and one tritonymph. Unfortunately, these types are in very poor condition. The chelal teeth of both specimens are nearly obliterated, making it impossible to ascertain their true nature. Further, the distal portions of the terminal teeth of every chelal and cheliceral finger of the female also have been destroyed.

ACKNOWLEDGMENTS

Appreciation is expressed to Herbert Levi of the Museum of Comparative Zoology, Cambridge, and to Norman I. Platnick of the American Museum of Natural History, New York, for the loan of specimens; to William B. Muchmore of the University of Rochester, and to Robert O. Schuster of the University of California at Davis for their continued cooperation in our study of Western American pseudoscorpions.

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THE MOLTING SEQUENCE IN *APHONOPELMA CHALCODES* (ARANEAE: THERAPOSIDAE)

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ABSTRACT

The molting sequence of *Aphonopelma chalcodes* is broken into ten steps and each characterized. Feeding is delayed several days after a molt as the exoskeleton hardens. Under artificial conditions molting may occur at any time during the day, but apparently occurs on a seasonal cycle.

INTRODUCTION

While several authors have investigated molting in the tarantula, the actual molting sequence has received little attention. Passmore (1939) gave three stages and illustrated them by photographs. Baerg (1958) gave a time of four hours for a tarantula to remain on its dorsum before the carapace began to lift, and one hour and fifteen minutes for the actual molt. The purpose of this work is to give a detailed account of the molting sequence for the species *Aphonopelma chalcodes* Chamberlin, and to present evidence that this event is highly seasonal in its occurrence, but may take place at any time of day.

METHODS

Presumed adult female tarantulas were maintained in wide mouth gallon jars and were fed crickets or tenebrionid beetles on a weekly schedule. The temperature the tarantulas were maintained at varied from 24-27°C.

OBSERVATIONS

A total of twenty-five molts occurred over a two year period, four of which were observed in detail. For convenience, the entire sequence was divided into ten stages, which are summarized in Table 1.

First Stage: On dorsum to carapace splits. A spider was first noted as preparing to molt when on its dorsum, no specimen being observed to molt without first positioning itself so. Rau (1925) reported a tarantula molting in an upright position; however, the observations of McCook (1887), Passmore (1939), Gertsch (1949), and Baerg (1958) agreed with mine that this was an exception to normal behavior.

While on its dorsum the spider was motionless, with the legs and pedipalps arranged symmetrically. The motionless spider then suddenly began to twitch the legs and pedipalps, and the chelicerae were erected perpendicular to the long axis of the body. At this time the carapace became detached both laterally and anteriorly.

Second Stage: Carapace splits to wrinkled abdomen. During this time the pedipalps and legs continued to move, with the coxae, positioned at opposite ends of a diagonal across the sternum, seeming to pull in opposing directions. This created a stretch across the sternum.

Third Stage: Wrinkled abdomen to new coxae free. All legs and pedipalps flexed and extended in unison (four complete cycles per minute), with each cycle exposing more of the new appendages. During this time a lateral rip sometimes occurred on each side of the abdomen, exposing part of the anterior lateral region of the new abdominal exoskeleton.

Fourth Stage: Coxae free to paturons free (Fig. 1). The motion cycles of the legs and pedipalps continued to expose more of these appendages, so that the leg trochanters became completely visible. Also, if it did not occur earlier, the old abdominal exoskeleton tore in the lateral area exposing the fresh abdominal exoskeleton with a renewed urticating hair patch, even though the patch may have been only a bald spot on the old exoskeleton (Cooke et al., 1972).

Fifth Stage: Paturons free to leg femora free. During this stage the fangs, white in color, were freed completely. The legs and pedipalps continued to pulsate in unison, exposing the new leg femora.

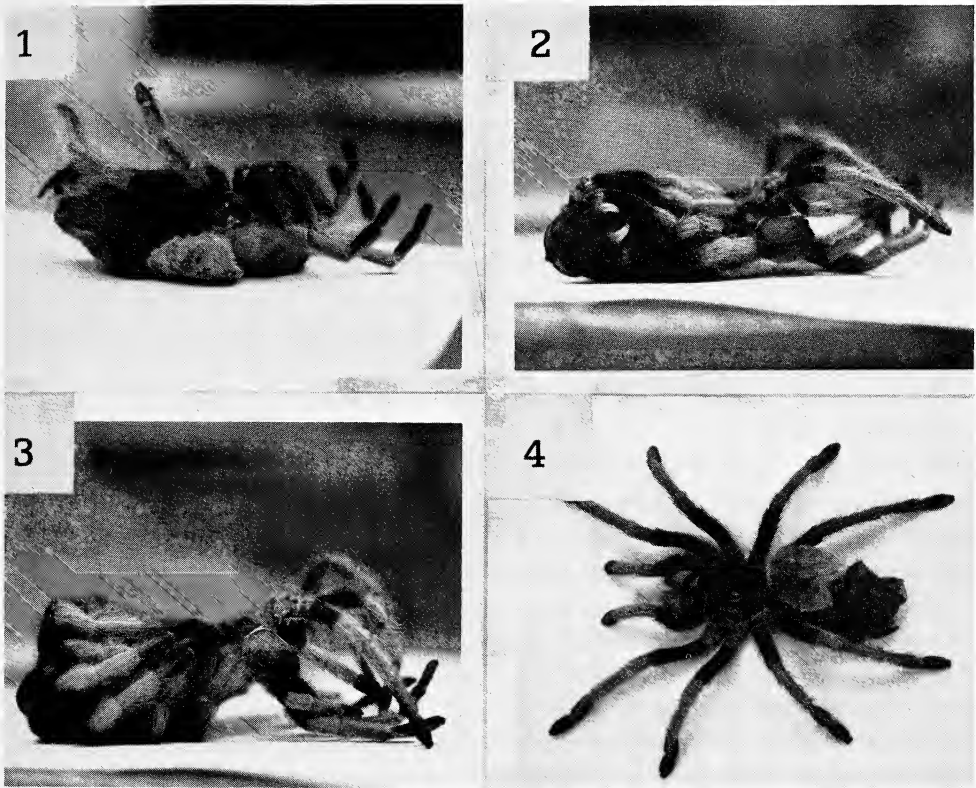
Sixth Stage: Leg femora free to leg patellae free. This was a fairly short phase, as the leg patellae are short segments. This act was accomplished by leg and pedipalpal pulsations.

Seventh Stage: Leg patellae free to leg tibiae free (Fig. 2). During this time the fang-tips became reddish brown. The pedipalps, which had been in advance of the legs throughout, were now completely free. There was one exception to this, in which the spider molted from the penultimate instar into an adult male. It is likely that the terminal bulb of the mature male pedipalp resulted in the observed delay in the removal of the pedipalp from the exuvium. Leg pulsations continued throughout this time, but the pedipalps began to move out of phase with the legs once they were completely free.

Eighth Stage: Leg tibiae free to metatarsi free. Along with the complete exposure of the metatarsi, the new spinnerettes became visible.

Table 1.—Summary of times (in minutes) spent in each molting stage by four specimens of *Aphonopelma chalcodes* in captivity.

STAGE	A	B	C	D
1. On dorsum to carapace splits	120	150	352	244-264
2. Carapace splits to wrinkled abdomen	10	30		6
3. Wrinkled abdomen to new coxae free	28			
4. Coxae free to paturons free	6			
5. Paturons free to leg femora free	10	9	10	26
6. Leg femora free to leg patellae free	7	1	6	
7. Leg patellae free to leg tibiae free	12		7	8
8. Leg tibiae free to metatarsi free	3			3
9. Metatarsi free to last leg free	15			8
10. Legs free to turns over to upright position	56	61	87	89
Total duration	267			



Figs. 1-4.—Molting in *Aphonopelma chalcodes*: 1, old carapace detached and new leg trochanters becoming visible; 2, new fangs and pedipalps free; 3, newly freed legs in flexed position alongside exuvium; 4, exuvium showing point of emergence from detached carapace.

Ninth Stage: Metatarsi free to last leg free. The legs and entire spider, became completely freed of the old exuvium. During this interval the fully formed male pedipalps were completely freed, with the bulb and embolus appearing white and resembling newly emerged fangs in color. During this stage leg pulsations were reduced in frequency to two complete cycles of motion per minute.

Tenth Stage: Complete extraction of legs from the exuvium to the spider righting itself (Fig. 3). During this time the legs were repeatedly flexed a number of times. Bristowe (1958) stated that these movements were vital to insure supple joints for the spider. Suddenly the spider righted itself over one side and was quiet, leaving the old exuvium behind (Fig. 4).

DISCUSSION

Passmore's (1939) first and third stages corresponded to my first and tenth stages, his second stage combined my second to ninth stages into one. Passmore observed the leg pulsations, but gave no rates nor mentioned the pedipalps. His single tarantula molted annually as did *A. chalcodes*.

Rau (1925) noted a fasting period of two weeks before a molt, and suggested the swallowing of air as a mechanism to cause the initial splitting off of the carapace. In

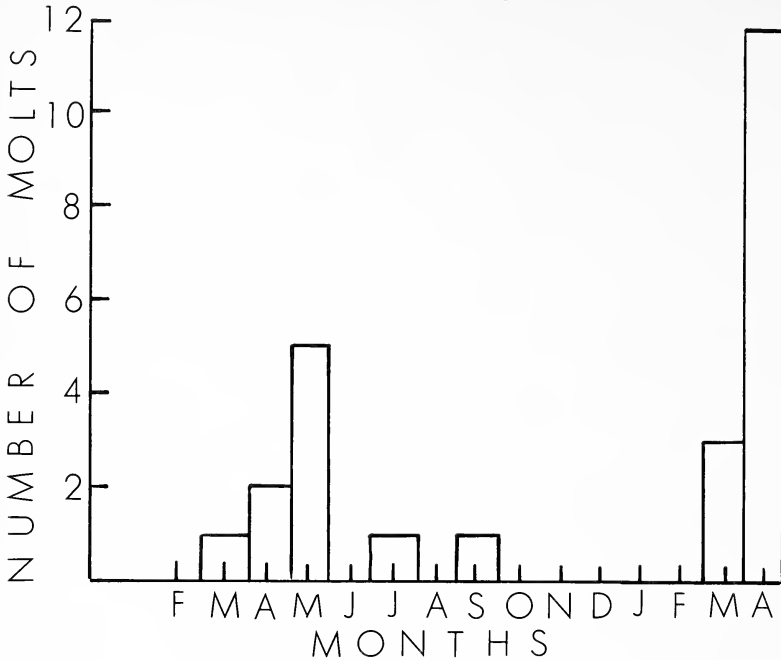


Fig. 5.—Frequency distribution of molts of presumed females by month (February 1975 to April 1976).

contrast, six *A. chalcodes* fasted prior to molting an average of twenty-nine days, ranging from seventeen to thirty-seven days.

McCook (1887) cited the unexplained death of a tarantula shortly after a molt. No mortality resulted from the twenty-five observed molts in *A. chalcodes*.

Gertsch (1949) stated that the tibial spur and palpal bulb indicative of the adult male were without a trace in the penultimate instar, in agreement with my own observations. The extraction of the pedipalps in adult males was delayed until the ninth stage. In presumed adult females this occurred during the seventh stage. Aside from this the molting sequence did not vary between the sexes.

In all cases but one the spider remained completely on its dorsum during the entire molting process, assuming this position five or six hours before the carapace split. In the single exception the spider was on its side while the legs were being extracted. This particular spider had been placed on a clean sheet of white paper to serve as a contrasting background for photographs, and since other spiders, in agreement with Gertsch (1949), were observed to rest on a thin sheet of web on soil substrate, I believe that this one case is an artifact resulting from an unnatural substrate. Further evidence for this interpretation comes from the observation that this specimen had difficulty in fully extracting the last leg from the old exuvium.

The next several days saw the new exoskeleton gradually harden. This was easily seen as the fangs darkened. One specimen caught and ate an adult cricket three days after its molt, and another four days after its molt.

Tarantulas seem capable of molting at any time of the day. Twenty-one of the twenty-five molts occurred either late at night or early in the morning and their sequence

was not observed. The molts I observed spanned a period from 11:00am to 10:00pm. Thus, there seems to be no particular time of day to which molting is restricted under artificial conditions for this species.

There does, however, appear to be a seasonal correlation with molting. Figure 5 shows the number of molts and the months in which they occurred, showing that molts are concentrated around the last half of March and throughout April. Two individuals were maintained long enough to molt twice, and in both cases the period between molts was approximately one year. Baerg (1963) indicated that the frequency of molts depends not only on the species of spider, but also on the age. Young of *Eurypelma californica* Ausserer may molt up to four times during their first year, while older juveniles of this species possess an annual molt cycle (Baerg, 1938, 1945). Senility may first manifest itself by the disruption of the regular molt cycle in tarantulas (Baerg and Peck, 1970).

ACKNOWLEDGMENTS

The author wishes to thank Dr. Willis J. Gertsch who kindly identified the species of tarantula used in this study. Dr. Oscar Francke took time out of his busy schedule to take the photographs. Also thanks should go to Dr. Mont Cazier who read this manuscript and offered a number of helpful suggestions for its improvement.

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THE CRIBELLATE GENUS *TENGELLA* (ARANEAE: TENGELLIDAE ?)

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ABSTRACT

The three described species of *Tengella* Dahl 1901, family Tengellidae(?), are reviewed. *Tengella perfuga* Dahl 1901 is known only from the original description. The male of *T. albolineata* (Pickard-Cambridge, 1902) is redescribed. The male of *T. radiata* (Kulczynski, 1909) is described, with a redescription of the female.

INTRODUCTION

The genus *Tengella*, erected by Dahl in 1901, was at first placed by him in the family Zoropsidae. Later (Dahl, 1908), he proposed the family Tengellidae for this genus. The psechrid genus *Metafecenia* Pickard-Cambridge, 1902, was synonymized with *Tengella* by Lehtinen (1967), who reduced Tengellidae to a subfamily of his new family Miturgidae. The Miturgidae include a group of genera which could not be accommodated in the Amaurobiidae or Liocranidae, as Lehtinen defined these families. He regarded the limitation of the family as preliminary, and stated "the splitting of Miturgidae is unavoidable" (Lehtinen, 1967).

The Tengellinae were characterized (Lehtinen, 1967) as having two tarsal claws and a distally notched labium. All *Tengella* species actually have three tarsal claws, a basally notched labium and a ventral spination pattern on the tibiae and metatarsi different from Lehtinen's characterization. As Lehtinen (1967) found tengellids to be "highly deviating types" from his Miturginae, the family name Tengellidae is considered to be preferable.

Placement within the Zoropsidae, a family of uncertain affinities, must also be discounted until further study and revision provide data for comparison. *Zoropsis* has two tarsal claws, anterior median eyes smallest, both eye rows recurved, and a different spination pattern. Lehtinen (1967) placed *Zoropsis* in a different superfamily (Lycosoidea) than tengellids (Amaurobioidea). *Zorocrates*, a genus related to *Tengella*, has commonly been listed in Zoropsidae but should also be in Tengellidae(?). Zorocratidae is also an available family name.

A revision and definition of *Zorocrates* is one necessary preliminary to proper placement of *Tengella*. Studies of other genera in the "families" Zoropsidae, Tengellidae and Miturgidae probably will be required also. The genera placed in these families contain primarily large and generalized spiders for which valid familial characters do not seem to

be available. The lack of specimens, biological information and the inadequate and incorrect data in the literature have created a confusion which renders any placement as provisional. Until specimens of *T. perfuga* are found, the status of *Tengella* and Tengellidae are in doubt, though these names are preferred over other unrecognizable groupings.

The information on *Tengella* presented here has the object of stimulating further collecting and field studies of the genus, facilitating recognition of the described species, and calling the group to the attention of araneologists. I hope that this will make possible further and more conclusive studies of the genus, and reveal its affinities more clearly.

Tengella Dahl

Tengella Dahl, 1901:251 (Type species: *Tengella perfuga* Dahl, 1901, by monotypy).

Metafecenia Pickard-Cambridge, 1902:356 (Type species: *Metafecenia albolineata* Pickard-Cambridge, 1902, by monotypy). Lehtinen, 1967:248, 268 (= *Tengella*).

Three species of *Tengella* have been described, *Tengella perfuga* Dahl 1901 from a female specimen, *Metafecenia albolineata* Pickard-Cambridge 1902 from a male, and *M. radiata* Kulczynski 1909 from a female.

Characteristics.—Three tarsal claws. Tarsi and distal third of metatarsi with scopulae. Legs I, IV, II, III. Tibiae I and II with 2-2-2-2 ventral spines, III and IV with 2-2-2 or 2-2-1. Metatarsi with 2-2-2 or 2-2-1 ventral spines. Occasionally spines are irregularly arranged. Trochanters are notched.

Cribellum bipartite. Calamistrum one third the length of metatarsi on proximal half, consisting of five rows of short curved bristles, although it is difficult to count discrete rows in some cases. Three anterior, four posterior cheliceral teeth. Chelicerae with boss. Labium notched basally, two thirds length of endites; width one half to three quarters of length.

Eyes, eight, arranged in two rows. Anterior row straight, posterior procurved. Anterior median eyes largest, others subequal.

Tengella perfuga Dahl

Tengella perfuga Dahl, 1901:252. Female holotype from 'South America,' lost.

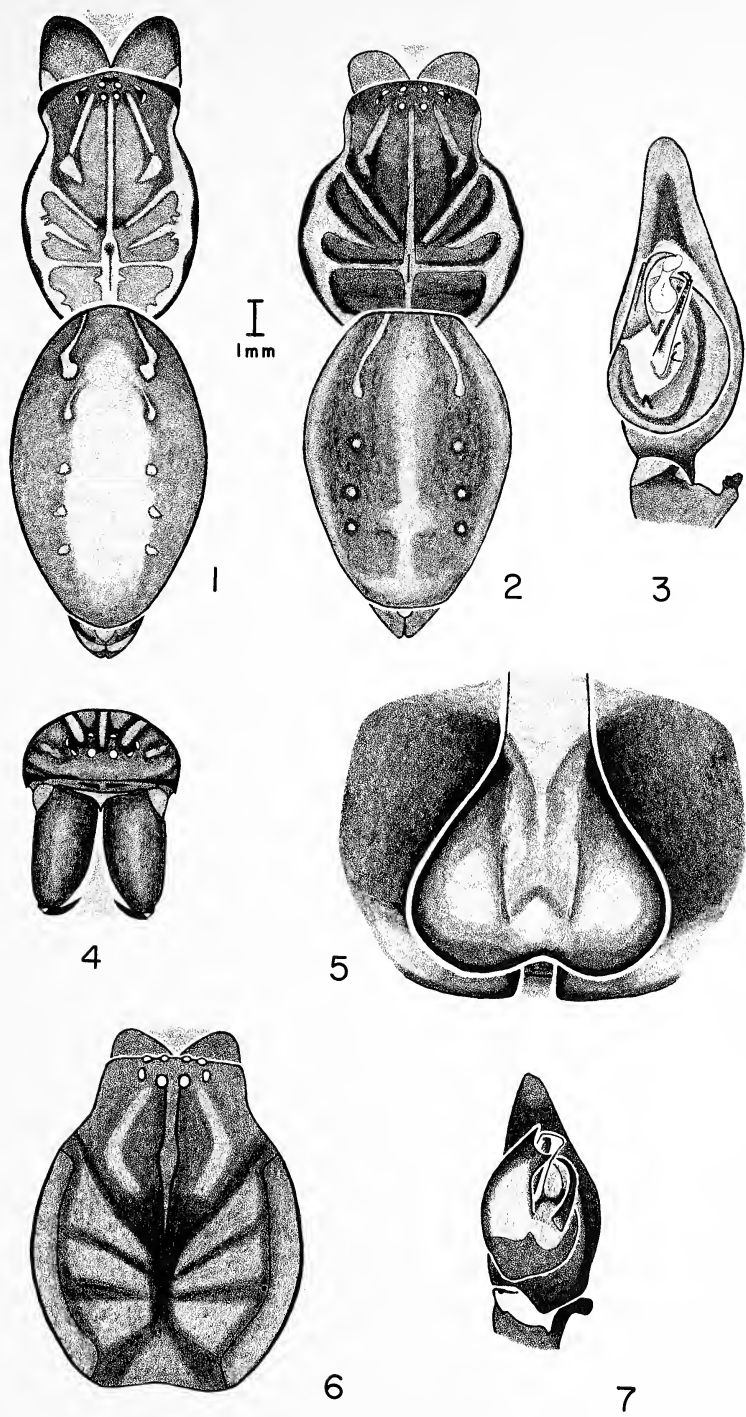
Discussion.—Dahl used the type to study internal anatomy; the specimen should be in the Berlin Museum, but is lost. No specimens are known, and a definitive description of this species will depend upon further collecting.

Tengella radiata (Kulczynski)

Figures 1-5

Metafecenia radiata Kulczynski, 1909:447, pl. 22, fig. 18. Holotype female from Sipurio de Talamanca, Costa Rica, not examined.

Tengella perfuga: Lehtinen, 1967:268, fig. 83 (not *T. perfuga* Dahl).



Figs. 1-5.—*Tengella radiata*: 1, dorsal view of female; 2, dorsal view of male; 3, palpus of male; 4, anterior view of female; 5, epigynum of female.

Figs. 6-7.—*Tengella albolineata*: 6, dorsal view of carapace of male; 7, palpus of male.

Diagnosis.—The synonymy of *T. radiata* with *T. perfuga* Dahl by Lehtinen (1967) is rejected. *T. radiata* differs in color pattern, as the distinctive radiating lines on the carapace are absent in *T. perfuga*. *Tengella perfuga* is slightly smaller. Location of the type is unknown, possibly in the Warsaw Museum.

Genitalia. Illustrated in Figures 3 and 5.

Structure. Measurements from six females and two males are in Table 1. Female clypeus 0.48-0.65mm, mean .55mm. Anterior eye row 1.5-2mm long, mean 1.8mm. Posterior eye row, 1.9-2.5mm, mean 2.3mm. Median ocular quadrangle, lateral side 0.8-1mm. Eye diameter, AME mean 0.38mm; PME mean 0.3mm.

Mean female leg length, I, 34.8mm; II, 27.3mm; III, 23.1mm; IV, 31.1mm. Mean segment length of leg IV, Femur 9.1mm, Patella-Tibia 10mm, Metatarsus 8.9mm, Tarsus 3.2mm.

Female.—Pattern illustrated in Figures 1 and 4. Carapace with yellow submarginal lines, and a light yellow median line which runs from between the PME to the posterior edge of the cephalothorax. Three pairs of yellow lines radiate from the median groove with all continuous with the submarginal lines, though only the third pair is often continuous with the median line. Short bands extend laterally from the ALE. A pair of lines originate between the PME and extend almost to the radiating lines.

The sternum is light brown with a median yellow line extending from the anterior edge almost to the posterior edge. Endites and labium are brown with distal ends lighter. The coxae are dark distally, but one specimen had unicolorous yellow coxae. The legs are pale yellow, with the dorsal surfaces of the femora and tibiae darker. Four annulations are on the femora and tibiae. Fading of the annulations on femora I and II occur, particularly in the larger specimens. Tibiae vary from no distinct annulations to four.

The dorsum of the abdomen is darker anteriorly. Two thin white lines run from the anterior edge and break into rows of five dots extending almost to the spinnerets. The fifth and sometimes the fourth pair of dots may be indistinct.

Male.—Pattern illustrated in Figure 2, description is same as female.

Records.—COSTA RICA. Alajuela: Alajuela, no date, one male (C. E. Valerio; Univ. of Costa Rica); Rio Angel, no date, three immatures (C. E. Valerio; UCR). Guanacaste: Tilaran, no date, two females (C. E. Valerio; UCR). Heredia: Pto. Viejo, no date, two immatures (C. E. Valerio; UCR). Puntarenas: San Vito, 27-31 July 1970, two females (C. E. Valerio; UCR); San Vito, no date, one female (C. E. Valerio; UCR); Monteverde, 11 November 1960, one female (C. W. Palmer; AMNH); Monteverde, 5 December 1960, one female (C. W. Palmer; AMNH). Tiribi, no date, three females (N. Banks Coll.; MCZ); Las

Table 1.—Measurements of six females and two males of *Tengella radiata* (in millimeters).

	Females		Males
	range	mean	
Body length	17.5-23.8	19.8	15.0, 17.5
Carapace length	7.4-9.0	8.5	7.5, 8.7
Carapace width	5.0-6.7	5.7	5.7, 6.4
Abdomen length	9.8-11.4	10.5	7.5, 8.8
Labium length	1.4-2.0	1.7	1.8, 1.8
Labium width	1.1-1.4	1.3	1.2, 1.3
Endite length	2.4-2.6	2.5	2.5, 2.7
Sternum length	3.0-3.5	3.2	3.2, 3.3
Sternum width	2.6-3.3	3.0	3.0, 3.1

Cruces, 1 February 1976, two females and one immature (V. Roth, B. Schroepfer; AMNH); San Rafael de Moravia, no date, one male and three immatures (C. E. Valerio; UCR).

Tengella albolineata (Pickard-Cambridge)

Figures 6-7

Metafecenia albolineata Pickard-Cambridge, 1902:357, pl. 33, figs. 16-17. Male holotype from Amula, Guerrero, Mexico in British Museum (Natural History), examined.

Tengella albolineata: Lehtinen, 1967:268, fig. 75.

Diagnosis.—*T. albolineata* is a much smaller species than *T. perfuga* and *T. radiata*. The male palpus, illustrated in Figure 7 is distinctive, as is the long hair on the venter of the palpal tibiae.

Structure. Two males, length 12mm, 14.4mm. Carapace length 5.8mm, 6.8mm; width 4.8mm, 6.8mm. Labium length 1.4mm, 1.7mm; width 0.9mm, 1mm. Endite length 2mm, 2.3mm. Leg length I, 45mm; II, 35mm; III, 30mm; IV, 42mm.

Male.—Color pattern illustrated in Figure 6. Carapace brown, with a light median line running from PME posteriorly to the deep cephalic groove. Lighter areas occur along the margin, some between the margin and cephalic groove, and a pair of lines originating between PME and PLE, are one third the length of cephalothorax. Sternum and legs are light yellow.

The abdomen has a pair of white lines which break into dots posteriorly.

Records—Mexico. Guerrero: Amula, no date, two males and one immature (H. H. Smith; BMNH).

ACKNOWLEDGMENTS

Deepest thanks go to Allen R. Brady for help, encouragement and for reviewing this paper. Helpful suggestions were made by Joseph A. Beatty. Thanks go to Nancy and Brooks Wheeler for translation of Kulczynski's original description and Wolfgang Schroeter for translation of Dahl's description. Specimens were loaned by Carlos E. Valerio, University of Costa Rica, N. Platnick, The American Museum of Natural History, F. R. Wanless, The British Museum (Natural History), and V. D. Roth, Southwestern Research Station. Marcia L. Wolff aided in preparation of the manuscript. The research was conducted while a student at Hope College and Western Michigan University.

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PREY OF THE JUMPING SPIDER *PHIDIPPUS JOHNSONI* (ARANEAE: SALTICIDAE)

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ABSTRACT

Field data indicate that *P. johnsoni* is an euryphagous predator, whose diet includes organisms (aphids, ants, opilionids) sometimes considered distasteful to spiders. Other spiders are preyed upon, including conspecifics. Prey size tends to be one quarter to three quarters the size of the predator.

INTRODUCTION

Since spiders are probably a dominant group of predators of insects (Bristowe, 1941; Riechert, 1974; Turnbull, 1973), there is considerable interest in their feeding ecology. Spiders have usually been considered to be euryphagous predators with a stabilizing, rather than regulative, effect on insect populations (Riechert, 1974). However, information concerning the prey taken by particular spider species, in the field, is limited. Field studies by Edgar (1969, 1970), Robinson and Robinson (1970) and Turnbull (1960) are especially noteworthy.

During the course of a study of the reproductive biology of *Phidippus johnsoni* (Peckham and Peckham) (Jackson, 1976), occasionally individuals of this species were found in the field holding prey in their chelicerae. Each prey discovered in this way is listed in Table 1. In addition, Ken Evans and Charles Griswold, who were familiar with this species, recorded observations of *P. johnsoni* with prey. (Their data are included in Table 1.) These data came from a variety of habitats in western North America, most of which have been described elsewhere (Jackson, 1976). It should be noted that observation of feeding in the field was a rare event. The results reported here are based on several thousand hours in the field, by the author. I found only 33 *P. johnsoni* with prey at the time of encounter, while over 4000 were found without prey. This number may be somewhat misleading, since a great many of these observations were carried out in the course of population censuses (Jackson, 1976). Censuses were generally carried out in the morning, when the spiders tended to be inside nests (retreats), built under rocks and in

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other similar places. Nests are tubular silk structures in which the spider resides at night, molts, oviposits, and mates. These devices are not known to function in prey capture in salticids. However, there were over 500 records of *P. johnsoni* observed outside nests, without prey, including observations at all times of the day. Possibly a feeding salticid is less prone to be in an exposed location than one that is not feeding, rendering observation of feeding in the field more difficult for the human observer. In the laboratory, when vegetation was present, it was noticed that feeding *P. johnsoni* tended to carry their prey under leaves and grass stems, although I do not have quantitative data concerning this.

Phidippus johnsoni is one of the largest and most commonly encountered salticid species in western North America. Adults tend to be about a centimeter in length and population densities range between two and thirty spiders per 1000 sp. m. (Jackson, 1976). Considering that *P. johnsoni* is apparently one of the most numerous spiders of its size range in many arthropod communities, the prey of this species is of particular interest.

RESULTS AND DISCUSSION

Casual observations in the laboratory suggest that adult males of *P. johnsoni* feed less frequently than immatures and adult females. This is probably a reflection of a life style that emphasizes locating females and mating. Field data are consistent with these observations, since no adult males were observed feeding in the field, although they were frequently observed outside nests. In contrast, fifteen immatures and eighteen adult females were observed with prey in the field.

There was great variation in the size of the prey relative to the predator. The greatest discrepancy was an incident of an adult female (11 mm in length) feeding on an aphid (approximately 2 mm in length). In some cases, *P. johnsoni* were observed with prey as large or slightly larger than themselves. In most cases, prey tended to be between one quarter and three quarters the size of the predator. This is consistent with Gardner's (1966) studies with *Phidippus coccineus* (Peckham and Peckham) using laboratory models.

Bristowe (1941) concluded that the major predators of spiders are other spiders. Evidently *P. johnsoni* prey heavily on spiders (Table 1, Fig. 1). Other *Phidippus* species (Tolbert, 1975) and other salticids (Bristowe, 1941) are known to enter the webs of some spiders and feed upon the occupants. Although this has not been seen in *P. johnsoni*, a suggestive observation was made. An immature *P. johnsoni* was found in the web of a *Dictyna*, walking on an egg sac, in and around which there were second instar spiderlings. In the laboratory, *P. johnsoni* fed readily on the spiderlings. Also, a *P. johnsoni* was observed feeding on an adult male of a web-building spider (Theridiidae), in the field (Table 1), but no webs were seen in the vicinity. Most likely, this male was searching for female webs when he was preyed upon.

Cannibalism, in the sense of females preying on conspecific males, figures heavily in hypotheses concerning the function of courtship in spiders (Bristowe, 1941, 1958; Platnick, 1971; Savory, 1928), and the significance of this factor in the mating strategy of male *P. johnsoni* has been discussed elsewhere (Jackson, 1976). Although three adult females were observed feeding on adult males in the field (Table 1), it should be noted that it is not known whether the male was courting at the time of the predatory attack. Predation may have occurred before the male detected the female's presence. In the

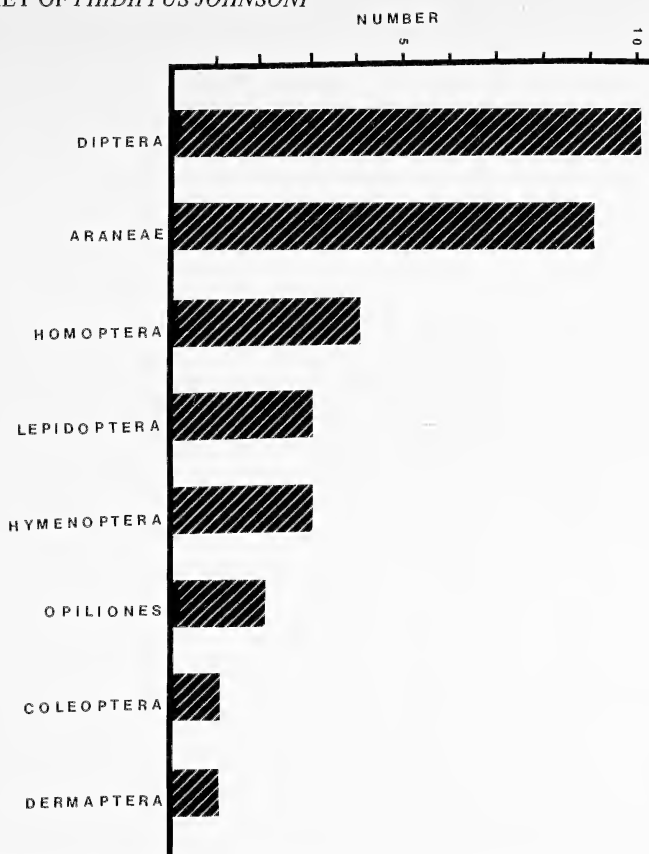


Fig. 1.—Representation of arthropod orders in the diet of *P. johnsoni*, based on 33 observations of predation in the field.

lycosid *Pardosa lugubris* (Walckenaer), Edgar (1969) observed frequent incidence of another type of cannibalism in the field, adults preying on conspecific immatures. This was not seen in *P. johnsoni*.

Although Bristowe (1941) noted that spiders generally find aphids, ants, and opilionids distasteful, each of these was eaten by *P. johnsoni* in the field (Table 1). Since a number of spider species, including the salticid *Stoidis aurata* (Hentz), are now known to consistently prey on ants (Edwards, *et al.*, 1974), Bristowe's conclusions should be viewed with caution. In the laboratory, *P. johnsoni* readily accepted aphids and opilionids collected from the same habitats as the spiders. In the single case of ant predation (Table 1), observed by Ken Evans, an immature spider fed while standing on a milkweed (*Asclepias*) stem. Subsequently, immature *P. johnsoni* in the laboratory were provided ants, collected from milkweed in other locations frequented by *P. johnsoni*. In each case, the ants were avoided, despite the fact that in some cases the spiders were kept without food for as long as two weeks previous to the tests. Laboratory spiders were also exposed to milkweed bugs (*Oncopeltus fasciatus* Dallas and *Lygaeus kalmii* Stål), both nymphs and adults. In each case, the spider either avoided or attacked then released the bugs.

Other *Phidippus* species have been reported to feed on Diptera, Hymenoptera, Coleoptera, adult Lepidoptera and especially larval Lepidoptera, in addition to some insects not reported for *P. johnsoni*, such as Odonata and Orthoptera (Bilsing, 1920; Edwards, 1975; Fitch, 1963; Kagan, 1943; Lincoln *et al.*, 1967; Warren, Peck and Tadic, 1967; Whitcomb, Exline, and Hunter, 1963; Whitcomb and Tadic, 1963). Considering the small

sample size, it may be cautiously proposed that Diptera numerically constitute the major prey of *P. johnsoni* (Fig. 1.). However, Araneae, Lepidoptera, and Hymenoptera may be more important when biomass is considered. Evidently, *P. johnsoni* is most accurately described as an euryphagous predator of insects and arachnids.

Table 1.—Prey of *P. johnsoni*. All prey are adults, unless otherwise noted.

	Total no.	% of total
INSECTA	22	66.67
Diptera	10	30.30
Culicidae	2	
Tipulidae	1	
Bibionidae	1	
Syrphidae	1	
Calliphoridae	1	
Anthomyiidae	1	
Unidentified calypterates	3	
Homoptera	4	12.12
Aphidae	4	
Lepidoptera	3	9.09
Unidentified larvae	2	
Unidentified moth	1	
Hymenoptera	3	9.09
Apidae (<i>Apis mellifera</i> L.)	2	
Unidentified ant	1	
Coleoptera	1	3.03
Cantharidae	1	
Dermaptera	1	3.03
Unidentified immature	1	
ARACHNIDA	11	33.33
Araneae	9	27.27
Lycosidae	4	
Salticidae	4	
<i>Metaphidippus</i> (immature)	1	
<i>Phidippus johnsoni</i> (adult male)	3	
Theridiidae (adult male)	1	
Opiliones	2	6.06

ACKNOWLEDGEMENTS

C. Griswold, K. Evans, R. L. Caldwell, S. E. Riechert, E. I. Schlinger, P. N. Witt, and G. B. Edwards are gratefully acknowledged for their comments and assistance. Thanks are extended to C. Griswold and R. C. Axtell for their assistance in the identification of insects. This work was supported in part by a NSF predoctoral fellowship.

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TWO NEW SPECIES OF *LYGROMMA* (ARANEAE, GNAPHOSIDAE)

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ABSTRACT

Two new species are described: *Lygromma tuxtla* from Mexico and *L. wygodzinskyi* from Colombia; the former species extends the known northern limit of the genus from Costa Rica to Chiapas.

INTRODUCTION

Since the completion of a revision of the spider genus *Lygromma* (Platnick and Shadab, 1976), two additional species of this unusual genus have come to light. One is from Chiapas, Mexico, and extends the range of the genus (formerly known on the mainland only from Peru north to Costa Rica) up to, and possibly beyond, the southern limit of its sister group, *Tivodrassus*, known only from Mexico. I am grateful to Dr. E. I. Schlinger and Mr. C. E. Griswold of the University of California, Berkeley, for their hospitality during a search of that collection that turned up the Chiapas specimens, and to Dr. M. U. Shadab for providing the illustrations.

Lygromma tuxtla, new species

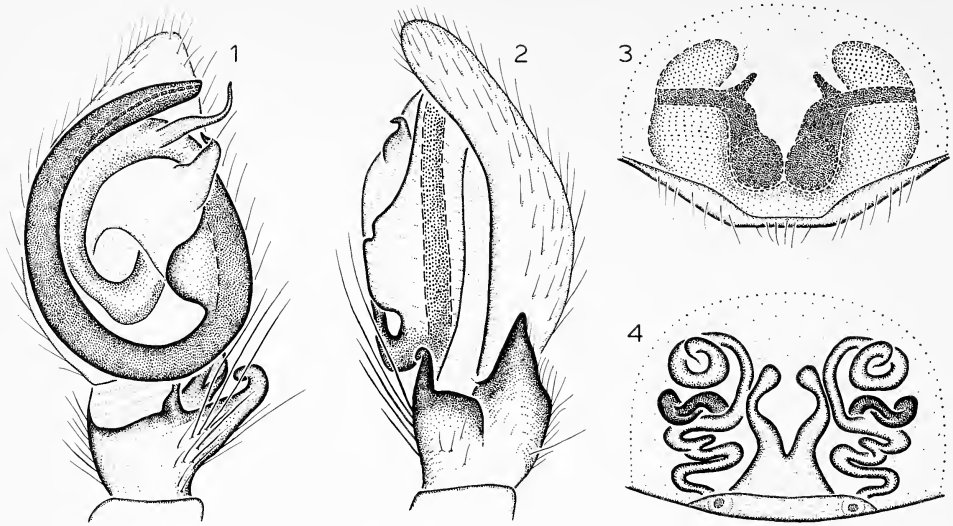
Figs. 1, 2

Type.—Male holotype from El Zapotal, near Tuxtla Gutiérrez, Chiapas, Mexico (15 July 1956; D. D. Linsdale), deposited in the Entomology Museum, University of California, Berkeley, on long-term loan to the California Academy of Sciences.

Etymology.—The specific name is a noun in apposition taken from the type locality.

Diagnosis.—*Lygromma tuxtla* resembles *L. peckorum*, *L. quindio*, and *L. kochalkai* in having a relatively long embolus and a translucent conductor; it may be distinguished from the first species by having only two retrolateral tibial apophyses (Fig. 2) and from the latter two species by the much wider embolus (Fig. 1).

Male.—Total length 2.33 mm. Carapace 1.01 mm long, 0.83 mm wide. Femur II 0.74 mm long. Anterior lateral eyes separated by two-thirds of their diameter. Embolus long, wide, originating retrolaterally, raised above tegulum (Fig. 1). Ventrally situated retrolateral tibial apophysis broadened basally, hooked distally; dorsally situated apophysis long, triangular (Fig. 2). Leg spination: femora III, IV p0-0-0, r0-0-0; tibiae: II v0-1p-0; IV vlp-2-2; metatarsi: III p0-0-1, r0-0-1; IV p0-1-1, v2-2-0.



Figs. 1-4.—1, 2, *Lygromma tuxtla*, new species, palp: 1, ventral view; 2, retrolateral view. 3, 4, *L. wygodzinskyi*, new species: 3, epigynum, ventral view; 4, vulva, dorsal view.

Female.—Unknown.

Material Examined.—Two juveniles taken with the holotype in Chiapas.

Lygromma wygodzinskyi, new species

Figs. 3, 4

Type.—Female holotype from an elevation of 3300 m on the road between Bogotá and Choachí, Cundinamarca, Colombia (13 July 1967; P. and B. Wygodzinsky), deposited in the American Museum of Natural History.

Etymology.—The specific name is a patronym given with great pleasure in honor of my colleague and friend, Dr. Pedro Wygodzinsky, collector of the holotype.

Diagnosis.—*Lygromma wygodzinskyi* resembles *L. peruviana*, *L. gertschi*, and *L. simoni* in having loosely coiled rather than symmetrically folded ducts; it may be distinguished from them by having six (rather than zero or eight) eyes and by the details of the epigynum (Figs. 3, 4).

Male.—Unknown.

Female.—Total length 3.31 mm. Carapace 1.15 mm long, 0.90 mm wide. Femur II 0.83 mm long. Eye pattern typical for six-eyed members of the genus. Epigynum with U-shaped duct outlines visible (Fig. 3). Spermathecal ducts loosely coiled (Fig. 4). Leg spination: femora III, IV r0-0-0; tibiae: II v0-2-0; IV vlp-2-2; metatarsi: III p0-1-2; IV r0-1-0.

Material Examined.—Only the holotype from Colombia.

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AERIAL DISPERSION OF SPIDERS IN NORTH CENTRAL TEXAS¹

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ABSTRACT

In a 365 day period 3400 ballooning spiders belonging to 14 families were collected in a suction trap. The four most common ballooning families were Erigonidae, Thomisidae, Oxyopidae, and Tetragnathidae. These four families make of 77% of the total. Peak periods of spider aerial dispersal occurred during early spring through early summer and late summer through fall. No information could be found on the ballooning activity of the family Mimetidae before this study. All thirteen other families had been reported previously.

INTRODUCTION

This study was designed to establish dispersion trends of families of spiders by month in North Central Texas. Several accounts of aerial dispersion (ballooning) are reported in the literature. The first was by Martin Lister in 1678 in his *Historiae Animalium Angliae* (see Crosby and Bishop, 1936). John Blackwall (1827) was the first to give an accurate account. McCook (1877, 1878), Emerton (1908) and Bristowe (1929) followed these early workers in publishing observations on spider ballooning. Duffey (1956) made one of the most extensive studies of aeronautic behavior of spider populations and related it to microclimatic conditions.

Most ballooning spiders are in early instars, second through fourth (van Wingerden and Vugts, 1974 and Horner, 1975). However, many adult spiders have been known to balloon, especially those in the families Linyphiidae and Erigonidae. The members of these two families are very small and this may account for their ballooning ability. Size is obviously one of the major restrictions to ballooning.

MATERIALS AND METHODS

Ballooning was studied by collecting the spiders in a Johnson-Taylor suction trap. The trap is 2.5 m tall, 55.8 cm in diameter, barrel shaped and has a fine mesh funnel screen

¹ Part of a thesis submitted by the senior author in partial fulfillment of the requirements for the M.S. degree in Biology at Midwestern State University.

terminating in a one pint jar of 70% ethyl alcohol. Air is pulled into the trap from several feet around the opening by a 0.33 h.p. electric motor driven fan.

The trap was located on the roof of the Science Building at Midwestern State University, Wichita Falls, Texas. The height of the roof of the building is 13.6 m above ground level. The surrounding area is made up of paved streets, buildings, parking lots, houses, grass lawns, and landscaped trees and shrubs. There is a small lake and pecan orchard approximately one kilometer southwest of the building. Primary original vegetation includes grasses and mesquite.

This study began on 10 June 1974 and concluded 9 June 1975. The specimens collected in June of the two years are grouped together as one month. The trap was run continuously for the year. Collections were made daily. Specimens were identified only to family. The large number of specimens collected, the great number of immature specimens, and lack of proper keys to the immatures made it impractical to key specimens to species.

RESULTS AND DISCUSSION

During the year 3400 specimens representing 14 families were collected. Representation ranged from one member of the family Mimetidae to 981 of the family Erigonidae. Two immature and partially damaged specimens, possibly of the family Erigonidae, remain unidentified.

Seasonal Dispersion.—The present study suggests that most spider families show two yearly peaks of aerial activity: one in late spring to early summer, and a second between mid-summer and fall. Only 57 of 3400 spiders were collected in January, February, and March (Table 1). These months are the coldest part of the year and low temperatures doubtless account for the low numbers of spiders taken.

Three percent of the total of 3400 spiders were collected in April. Nine of 14 families were represented. Sixty of the 110 spiders caught were erigonids (Table 1).

May was the first month that heavy ballooning could be observed, with 539 specimens collected. Taken in May were 315 erigonids, 170 tetragnathids, 14 linyphiids, and 99 specimens of other families (Table 1).

June collections contained representatives of 13 families, more than any other month. Only the Clubionidae were not represented. June collections also yielded the second largest number of spiders, 607, or 18% of the total. Families with their highest peaks in June were Theridiidae (21 of 39), Lycosidae (38 of 149), Araneidae (75 of 190), and Anyphaenidae (7 of 27).

The largest number of Salticidae (47 of 254 and Dictynidae (4 of 24) were collected in July. Of the 3400 spiders, 2854 or 84% of the total were caught from May through October. These six months include the peak periods of aerial activity for every family except Gnaphosidae. Of the 2865 spiders taken from May through October only 239 (7%) were taken in July and 198 (6%) in August. The highest daily temperatures for North Central Texas are usually recorded in July and August. The only family whose representation increased during July and August was the Dictynidae with eight collected in July and seven in August.

More specimens (667) were taken in September than in any other month (Table 1). Weather conditions are usually mild at this time. The only real peak of the year for the oxyopids occurred in September when 239 of 568 were taken. Active dispersal of nearly every family took place in September, even if an early summer peak had occurred.

Table 1.—Summary of spiders ballooning by month, including the total number of each family.

Family	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Erigonidae	27	1	12	60	315	159	23	62	120	83	104	15	981(29%)
Thomisidae	2	2	3	9	13	61	69	35	124	187	81	4	590(17%)
Oxyopidae	1	-	-	2	4	76	18	8	239	151	67	2	568(17%)
Tetragnathidae	2	-	-	11	170	105	12	7	76	46	37	16	482(14%)
Salticidae	1	-	2	13	10	47	96	34	20	26	2	3	254(8%)
Araneidae	-	1	-	4	37	75	4	4	34	23	6	2	190(6%)
Lycosidae	-	-	-	2	29	38	2	23	26	22	6	1	149(4%)
Linyphiidae	-	1	1	7	15	12	1	2	14	12	10	4	79(2%)
Theridiidae	-	-	-	-	-	21	3	10	4	1	-	-	39(1%)
Anyphaenidae	-	-	-	-	3	7	2	4	4	3	4	-	27(<1%)
Dictynidae	-	-	-	-	1	4	8	7	4	-	-	-	24(<1%)
Gnaphosidae	-	-	-	2	2	1	-	2	-	-	4	-	11(<1%)
Clubionidae	-	-	-	-	-	-	-	-	2	1	-	-	3(<1%)
Mimetidae	-	-	-	-	-	1	-	-	-	-	-	-	1(<1%)
Unknown	-	-	1	-	-	-	1	-	-	-	-	-	2(<1%)
Monthly Total	33	5	19	110	599	607	239	198	667	555	321	47	3400

October was a month of high activity with 16% (555) of the total number of spiders taken then. Most families showed a slight decrease from September. The Thomisidae, an exception, were most active during this month and 187 were captured.

Marked decrease in ballooning activity occurred in November and December, when only 321 and 47 spiders were caught. The gnaphosids alone showed increased ballooning activity during November when four individuals were taken.

Family Dispersion.—Family taxonomy is essentially that of Kaston (1972).

Erigonidae (Micryphantidae).—The erigonids were the most common spiders taken in the suction trap (981 of 3400). This group and the Thomisidae were the only families taken every month of the year. Peak ballooning was in May with 315 taken. A second and much smaller peak occurred from September through November. The erigonids included many more adult ballooners than the other groups. This probably accounts for the large number caught, since both mature and immature erigonids commonly balloon.

Thomisidae.—The thomisids were the second most common spider captured (590 of 3400). Rather than the two distinct ballooning peaks that most spiders exhibit, thomisids shows one peak from April to November, with a drop in activity in the month of August. From September through November 392 crab spiders were taken, with 187 in October alone.

Oxyopidae.—A total of 568 lynx spiders was taken in the trap. The family is the third most common ballooner in North Central Texas. Ballooning activity of the oxyopids showed one of the most dramatic seasonal changes. Eight individuals were taken in August, versus 239 in September and 151 in October.

Tetragnathidae.—The greatest ballooning activity by the tetragnathids occurred in May (170) and June (105). An increase in activity again occurred in September (76) and October (46). Tetragnathids balloon year-round except February and March. This was the fourth most common ballooning family.

Salticidae.—The salticids taken numbered 254. The highest ballooning activity was from June to October. A definite peak in activity occurred in July, with 96 spiders taken then.

Araneidae.—The araneids are year-round ballooners. As most other families, they have two peak periods, one in early summer and the other in early fall. Except during these peak periods, the numbers that balloon seem to be relatively consistent throughout the rest of the year.

Lycosidae.—As in most families, two peaks in ballooning activity were shown. A total of 149 specimens was recorded. The first and largest peak is in May (29) and June (38). The second peak occurred in August (23), September (26), and October (22). Lycosids balloon rarely between November and April, and only nine were taken in these six months.

Linyphiidae.—Only 79 linyphiids were captured. Members of this family apparently balloon year-round. Their major ballooning period was September to November.

Theridiidae.—The 39 theridiids captured were taken from June through October (Table 1). One half of the specimens were taken in June.

Anyphaenidae.—Twenty-seven anyphaenids were captured during the year. June marked the highest point of activity when seven were caught. None were taken from December through April.

Dictynidae.—The dictynids are not common ballooners in the North Central Texas area at any time of the year. Only 24 dictynids were taken from May through September.

There is apparently a single midsummer peak in July and August. The Dictynidae is the only family to show this pattern.

Gnaphosidae.—The gnaphosids were not consistent with the general trends shown in other families. This is probably due to the small sample size (Table 1). Glick (1939) reported that gnaphosids were taken in aerial samples. His study and the present one are the only records of their dispersion known to us.

Clubionidae.—Only three clubionids were caught. Of the three, two were taken in September and one in October. According to Peck and Whitcomb (1970), the largest number of young *Chiracanthium* are found between August and September.

Mimetidae.—Only one mimetid was taken during the study. This is the only family of spiders found in this study (so far as we are aware) that had not previously been reported to balloon. The immature specimen was taken in June, the month of heaviest ballooning dispersal.

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***TYPHLOCHACTAS SYLVESTRIS*, A NEW EYELESS SCORPION
FROM MONTANE FOREST LITTER IN MEXICO
(SCORPIONIDA, CHACTIDAE, TYPHLOCHACTINAE)**

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ABSTRACT

A new species of eyeless scorpion, *Typhlochactas sylvestris*, is described from a montane forest litter habitat in the Sistema Montañoso Poblano Oaxaqueño, Oaxaca, México. It is compared to the other three species, all cave dwellers, in the genus. A revised diagnosis of the genus *Typhlochactas* Mitchell is given, and *T. rhodesi* Mitchell, 1968, is designated as its type-species.

INTRODUCTION

The purpose of this paper is to present the description of yet another blind and depigmented scorpion of the genus *Typhlochactas* Mitchell, 1968.

Typhlochactas is the only scorpion genus to contain species entirely devoid of eyes and is the only genus in the subfamily Typhlochactinae, family Chactidae. To date, there are three species, all Mexican cave forms, referred to this genus: *T. rhodesi* Mitchell, 1968, from La Cueva de la Mina in Tamaulipas; *T. reddelli* Mitchell, 1968, from La Cueva del Ojo de Agua de Tlilapan in Veracruz; and *T. elliotti* Mitchell, 1971, from El Sótano de Yerbaniz in San Luis Potosí.

In May of 1971, a single individual of another, and quite distinct, species (Fig. 1) was found in montane forest litter in the state of Oaxaca during a field trip undertaken by one of us (SBP) as part of a long-term study of the distribution and ecology of scavenging and litter-inhabiting arthropods of tropical American forests. Thus, the scorpion described herein is unique in that it is the only known eyeless epigean scorpion.

Typhlochactas sylvestris, new species

Figs. 1-13

Coloration.—Uniformly pale yellowish-brown in life and similar, but somewhat paler, in alcoholic preservative.

Carapace (Fig. 2).—Poorly sclerotized and smooth. Anterior corners rather sharply rounded. Length approximately equal to width. Anterior margin with poorly defined epistome. Lateral margins diverging posteriorly. Very slight median groove. Median and lateral eyes lacking.

Preabdomen (Fig. 1).—Tergites weakly sclerotized and smooth. Lateral and posterior margins and surfaces with small setae. Sternites weakly sclerotized, smooth, and with small setae. All sternites with essentially straight posterior margins. Small, circular spiracles.

Postabdomen (Figs. 1, 10).—Segments with weak dorsal keels; no ventral or lateral keels. Few small granulations on dorsal keels. Many setae on all surfaces of segments. Each segment of greater length than preceding one, this most exaggerated with segment V. Segments I through IV progressively decreasing in width. Segments I through III each wider than long. Segment IV very slightly longer than wide. Segment V nearly twice as long as wide, more than one-third length of postabdomen, and approximately same length as carapace.

Telson (Fig. 1, 10).—Telson rather large, slightly longer than caudal segment IV. Aculeus moderately sclerotized. Vesicle flat dorsally, bulbous ventrally, and width exceeding depth. Many rather long setae occurring laterally, ventrally, and posteriorly on vesicle.

Pectines (Fig. 3).—Essentially unsclerotized. Each comb of five distinctly separate pieces, three marginal and two middle lamellae, fulcra absent. Five teeth on each comb, distal tooth largest, followed in size by proximal one. Remaining three teeth slender and of approximately same size. Each tooth bearing on anterior two-thirds of ventral surface several small setae and on posterior one-third patch of dense sensory tubules. Basal piece with pair of long setae.

Sternum (Fig. 3).—Pentagonal, with lateral margins converging slightly anteriorly; length about same as width. With posteromedial depression. Several small setae and paired long setae near anterior and posterior corners.

Genital Operculum (Fig. 3).—Female operculum much wider than long; with a strong anteromedial depression. Opercular halves fused into a single plate with no indication of suture. Several small setae on surface.

Chelicerae (Figs. 6, 7).—Length of basal portion of second joint slightly longer than width. Length of fixed finger slightly more than one-half that of movable finger. Fixed finger with only three teeth on superior margin: distal, median, and basal. Subdistal tooth, present in all other scorpions, absent. Median and basal teeth not combining to form compound tooth. Inferior margin lacking teeth. Tuft of long hairs on basal half of medial surface of fixed finger; ventral surface with long hairs sweeping onto venter of basal portion of joint. Movable finger with strong distal tooth on inferior margin; remainder of this margin without teeth. Superior margin with four teeth: distal, subdistal, median, and basal. Subdistal, median, and basal united to form a single compound tooth. [In holotype, and only specimen of this species, this dentition represented only on right movable cheliceral finger; on left finger projection representing basal tooth absent.] Distal tooth of superior margin of movable finger well removed from tip of finger. All teeth of both fingers, other than distals, quite small. Serrula present on venter of movable finger extending three-fourths length of finger. Basal three-fourths of venter of movable finger clothed by long hairs. Several setae on dorsal surface of second joint and on movable finger.

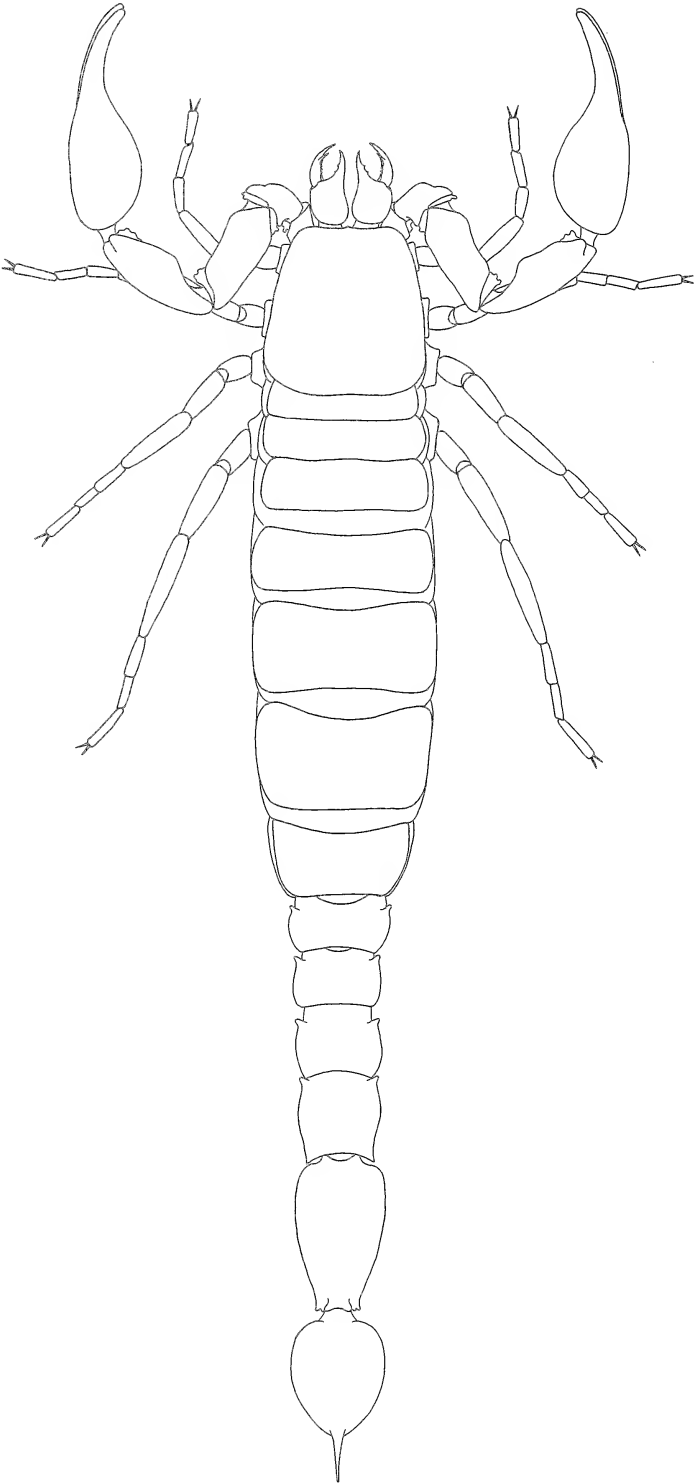
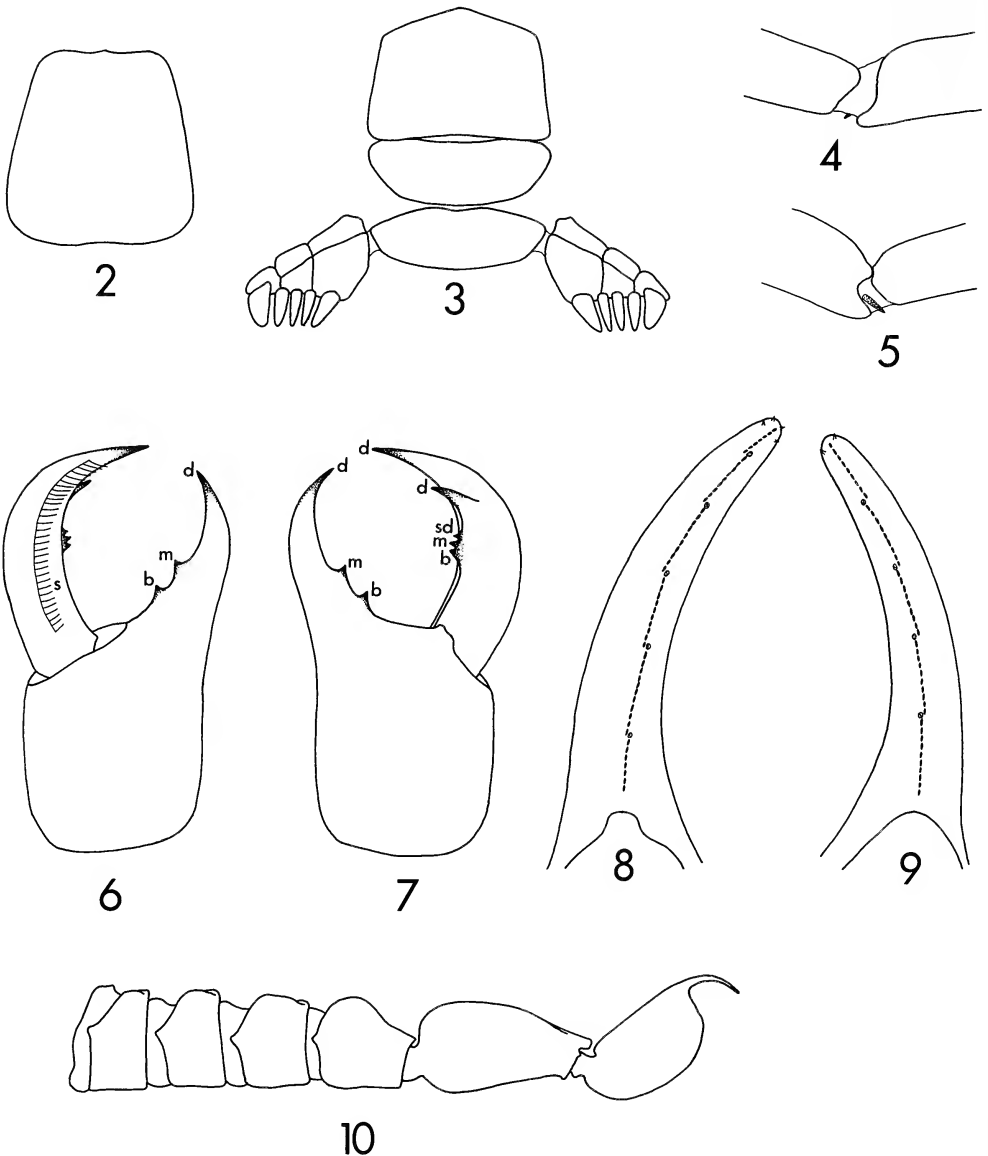


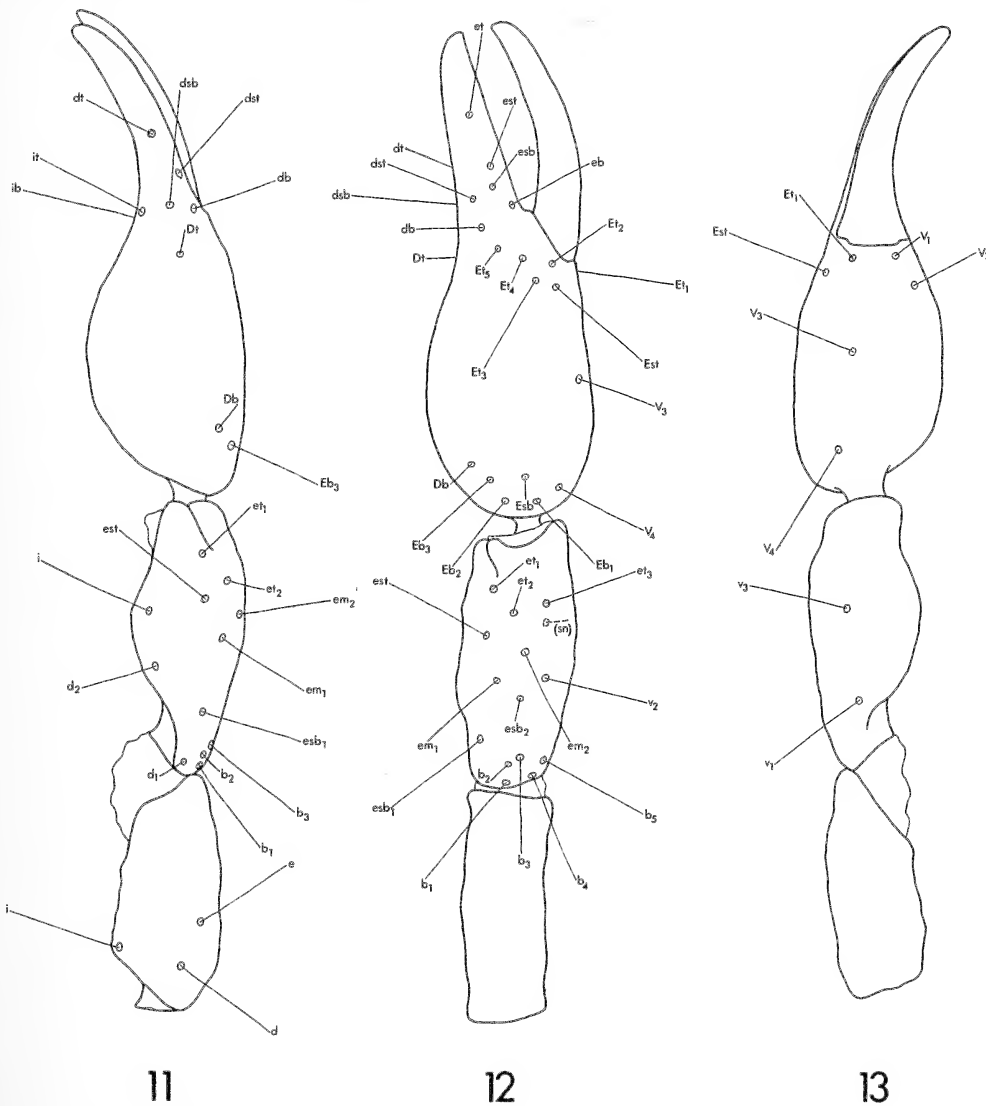
Fig. 1.—*Typhlochactas sylvestris*.

Pedipalps (Figs. 8, 9, 11, 12, 13).—Trichobothrial pattern basically that of Vachon's Orthobothriotaxia, Type C (Vachon, 1974). Ventral tibial trichobothrium v_2 present on external face of tibia. [This is true for all species of *Typhlochactas* as Vachon (1974:932) has pointed out for *T. reddelli*.] [On the right tibia of the holotype there occurs an additional, short trichobothrium proximal to et_3 (sn of Fig. 12). This trichobothrium is not present on the left tibia. We attach no significance to the occurrence of such a



Figs. 2-10.—*Typhlochactas sylvestris*: 2, carapace; 3, sternum, genital operculum, pectines; 4, articulation of left basitarsus and tarsus, leg IV, retrolateral; 5, articulation of right basitarsus and tarsus, leg IV, prolateral, showing basitarsal spur; 6, right chelicera, ventral. Tooth designations in this and Fig. 7 as follows: *d*, distal; *sd*, subdistal; *m*, median; *b*, basal; *s* indicates serrula; 7, right chelicera, dorsal; 8, movable finger of left pedipalp showing tooth files; 9, fixed finger of left pedipalp showing tooth files; 10, postabdomen, lateral.

supernumerary trichobothrium.] Femur slightly shorter than tibia; slightly more than twice as long as deep. Few granules on inner face. Dorsal carinae poorly developed. All surfaces with setae. Tibia only slightly more than twice as long as deep; less granulated than femur. All surfaces with small setae. Hands short, one and one-third times length of carapace. All carinae poorly developed, few prominent granules. All surfaces with moderate setation. Movable finger six times as long as midpoint width, shorter than carapace, only slightly longer than palm. Dentate margin unscalloped, armed with six very slightly oblique files of teeth. Distal file shortest, followed in length by basal file. Other four files longer and of approximately same length. Fixed finger six times as long as midpoint width; slightly shorter than movable finger. Dentate margin unscalloped and with five tooth files, each about same length.



Figs. 11-13.—*Typhlochactas sylvestris*, right pedipalp showing trichobothria. Symbols as follow: *b*, basal; *D*, *d*, dorsal; *E*, *e*, external; *i*, internal; *m*, median; *s*, sub; *t*, terminal; *V*, *v*, ventral; *sn* indicates supernumerary trichobothrium. First letter of symbols for palm trichobothria capitalized. 11, dorsal view; 12, external view; 13, ventral view.

Legs (Figs. 4, 5).—All surfaces with moderate setation. No tibial spurs. Prolateral basitarsal spurs present; no retrolateral spurs. Venter of tarsi with two irregular rows of rather stout setae; no midventral row of spines or spicules. Median claw very well developed.

Etymology.—Specific name from *sylvestris*, Latin indicating living in the woods.

Type Locality.—25 km S village of Valle Nacional at 1200 m along Highway 175, which connects Oaxaca and Tuxtepec, Oaxaca, México, across the Sistema Montañoso Poblano Oaxaqueño. Holotype and only known specimen taken on 21 May 1971 by Stewart B. Peck from a Berlese sample (#204) comprised of a total of 27 l of sifted leaf litter.

Type Deposition.—Holotype, female, deposited in the Museum of Texas Tech University.

TRICHOBOTHRAL DESIGNATIONS

This paper employs Vachon's (1974) latest system for the designation of pedipalpal trichobothria and consequently there are considerable changes from those designations used by Mitchell (1968, 1971) for the three previously described species of *Typhlochactas*. The changes from former usage to the present usage are as follows: Femur: change d_1 to d and d_2 to e . Tibia: change b_1 to b_5 , b_2 to b_4 , b_4 to b_1 , b_5 to b_2 , sb to esb_1 , m_3 to esb_2 , m_4 to em_1 , m_2 to em_2 , m_1 to v_2 , st_3 to est , st_1 to et_3 , st_2 to et_2 , t to et_1 , and v_2 to v_3 .

REVISED GENERIC DIAGNOSIS

The original diagnosis of the genus *Typhlochactas* Mitchell, 1968, has been outdated by the subsequent discovery and description of *T. elliotti* Mitchell, 1971, and *T. sylvestris* Mitchell and Peck. No diagnosis of the genus *Typhlochactas* written in such a manner as to include all four presently described species can be entirely satisfactory. Each species presents its own unique features, features of considerable importance in scorpion taxonomy. For example, *T. sylvestris* has an entire genital operculum; the other species, a divided operculum. *T. rhodesi* and *T. elliotti* lack basitarsal spurs; the other two species have a prolateral spur. *T. reddelli* has the median and basal teeth fused to form a compound tooth on the superior margin of the fixed cheliceral finger; the other species have these teeth separated. Thus, it seems at present that there are but two reasonable alternatives, maintain a single genus—perhaps one so heterogeneous as to be artificial, or separate each species into its own genus. For the present, we choose the former course.

Typhlochactas Mitchell, 1968

Revised Diagnosis.—Color pale. Sclerotization weak. Keel and granule development poor. Eyes absent. Spiracles subcircular to circular. Caudal segments with weak dorsal keels; other keels absent. Pectines reduced, combs of few pieces; with four or five teeth. Sternum large, pentagonal. Female genital operculum entire or of two valves. Superior margin of fixed cheliceral finger with three or four teeth, subdistal may be lacking; median and basal teeth separate or forming compound tooth; inferior margin lacking teeth. Superior margin of movable cheliceral finger with four or five teeth: distal, one or two subdistals, median, and basal; inferior margin with only large distal tooth. Serrula

present on venter of movable cheliceral finger. Pedipalpal trichobothrial pattern basically that of Vachon's *Orthobothriotaxia* Type C (Vachon, 1974). Prolateral basitarsal spur present or basitarsal spurs absent. Venter of tarsus with two regular to irregular rows of bristles.

Type species.—*Typhlochactas rhodesi* Mitchell, 1968. (by subsequent designation.)

HABITAT DESCRIPTION

The northeast facing slope of the outer range of the Sistema Montañoso Poblano Oaxaqueño is covered with forest ranging from lowland rain forest, through middle elevation montane cloud forest, to high elevation pine and fir forest. Additional description is given by Ball and Whitehead (1967). At a point 25 km south of Valle Nacional, Highway 175 travels along the southeast face of a ridge that it crosses through a saddle at 1200 m to then continue on the northwest face of the ridge. At the saddle, foot trails extend from each side of the road into a mixed-species cloud forest containing much oak (Fig. 14). In this area leaf litter was sifted and collected at two sites. The first site was an accumulation of loose decaying leaves lying along a log on a steep, well drained hill slope. About 12 l (about 25 kg) of sifted litter were collected here. The second site was a 3 m² flat area with poorer drainage. The litter here was about 5 cm thick and comprised of undecomposed and uncompacted leaves overlying a 10 to 14 cm thick spongy humus and root mat, which could be rolled like a rug from a light colored clay soil. About 15 l (about 30 kg) of litter were collected here.

The litter from these two sites was pooled into a single sample, which was placed into metal "Tulgren" Berlese funnels and then exposed to sunlight for eight hours for extraction of the fauna. The extracted litter was examined by hand the next day to determine what arthropods had not been driven out by the exposure to sunlight. The blind scorpion was found during this final hand sorting of the litter.



Fig. 14.—Characteristic montane litter habitat at the type locality of *Typhlochactas sylvestris* in the Sistema Montañoso Poblano Oaxaqueño, Oaxaca, México.

Table 1.—Measurements in mm of the holotype of *Typhlochactas sylvestris*.

Total length (=Carapace L + Preabdomen L + Postabdomen L + Telson L)	11.05
Carapace: length/width	1.22/1.25
Preabdomen: length	5.43
Postabdomen: length	3.06
Caudal segment I: length/width	0.32/0.83
Caudal segment II: length/width	0.40/0.70
Caudal segment III: length/width	0.45/0.67
Caudal segment IV: length/width	0.68/0.63
Caudal segment V: length/width	1.21/0.68
Telson length (=Vesicle L + Aculeus L)	1.34
Vesicle: length/width/depth	0.88/0.72/0.52
Aculeus: length	0.46
Pedipalp length (Femur L + Tibia L + Hand L)	3.64
Femur: length/depth	0.91/0.41
Tibia: length/depth	0.99/0.45
Hand length (=Palm L + Fixed finger L)	1.74
Palm: length/width/depth	0.86/0.58/0.63
Fixed finger: length/width (midpoint)	0.88/0.14
Movable finger: length/width (midpoint)	0.95/0.16
Chelicera length (Chela L + Fixed finger L)	0.65
Chela: length/width	0.40/0.31
Fixed finger: length	0.25
Movable finger: length	0.43
Sternum: length/width	0.41/0.63
Pectines: basal piece width/comb length	0.50/0.45

Because the litter from the two sites was combined, it is not known from which area the scorpion came, but it was observed that arthropods were more diverse and abundant in the better-drained hillside location.

At the several elevations where samples were taken in the forest along the road above Valle Nacional, there was found a rich fauna of relict and endemic species, at least in the beetle families Scarabaeidae and Leiodidae, for which there exist the best collection and taxonomic data. This same road is also one of the two known localities for native terrestrial amphipods in continental North America (Peck, unpublished data). These occurrences, together with that of the blind scorpion, indicate that the region can well be expected to yield many other species of exceptional distributional and evolutionary interest.

Blind litter-inhabiting scorpions are no doubt scarce to rare as the blind cave scorpions also seem to be. The rarity of the single specimen can better be appreciated by documenting the amount of collecting, using the same methods, that preceded and followed its discovery. The field program of litter sampling (of Peck), between 1969 and 1972, has led to extraction of fauna from 816 kg (2035 l) of sifted forest litter in México, El Salvador, Guatemala, and Belize from low, middle, and upper elevation forests.

DISCUSSION

The relationships of the new blind forest-litter scorpion to the blind cave-dwelling species is of obvious interest and significance. The epigeal species differs in several morphological features. *Typhlochactas sylvestris* is the most robust species in the genus. This is most apparent in the pedipalps and body segments. In this general feature *T.*

sylvestris is most similar to *T. reddelli*. The trichobothrial pattern of *T. sylvestris* is also most similar to that of *T. reddelli*. This is probably nothing more than a reflection of similar degrees of pedipalp attenuation (or actually lack of it) between the species. Mitchell (1971) has already shown that the most disparate trichobothrial pattern in the genus (*T. elliotti*) is probably the result of pronounced pedipalpal elongation. In the cave species there is great loss of distinctness of the pieces of the pectinal combs, whereas five pieces are distinct in each pectinal comb of *T. sylvestris*. All species have five pectinal teeth except *T. elliotti*, which may have four or five. The number of teeth on the fixed and movable fingers of the chelicerae is fewest in *T. sylvestris*, where the subdistal tooth is lacking on the superior margin of the fixed finger and one subdistal tooth (sd_1) is lacking on the superior margin of the movable finger. The median and basal teeth of the superior margin of the fixed cheliceral finger are separate and distinct in *T. sylvestris* as they also are in *T. elliotti* and *T. rhodesi*. They are fused in *T. reddelli*. Prolateral basitarsal spurs are possessed by *T. sylvestris* and *T. reddelli*; basitarsal spurs are lacking in *T. rhodesi* and *T. elliotti*. In summary, *T. sylvestris* appears to be somewhat more similar to *T. reddelli* than to the other two species. *T. sylvestris* is distinct from all of the other species in having an entire genital operculum.

In attempting a speculative reconstruction of the evolutionary history of these eyeless scorpions, one must bear in mind that the four species appear to represent a rather compact morphological group, even though each has its own anomalous characteristics. There are at least sufficient similarities to suggest that the four species are of common descent, if not from a single ancestral species then from closely related ones. Based on the distribution and characteristics of the species of *Typhlochactas*, it is most plausible to argue that the ancestral species inhabited montane litter, where they were widespread. It is entirely possible that these ancestral species may have partially or wholly lost their eyes and pigment as a consequence of adaptation to a cool and moist litter habitat because these characteristics appear frequently in other taxa containing "litter adapted" species such as beetles, collembolans, and millipedes. Such "preadaptation" may have aided litter inhabitants in cave colonization provided that they could have also withstood behaviorally and physiologically the different set of selection pressures of the cave environments. At the least, the existence of *T. sylvestris* admits to the possibility that the ancestors of the cave species could have been eyeless and depigmented prior to their invasion of the cave environment. On the other hand, the recent discovery of an eyeless diplocentrid scorpion in Yucatán by J. Reddell, D. McKenzie, and S. Wiley (Francke, 1977) seem to refute the notion that a scorpion *must* have acquired eyelessness and depigmentation in montane litter prior to cave colonization because no such habitat has been available in Yucatán.

To whatever extent the ancestors of *Typhlochactas* may have been "preadapted" to cave existence, they must have been, at the very least, montane forest litter dwellers. This is the only argument consistent with *T. elliotti* showing the greatest degree of cave adaptation, as well as *T. sylvestris* the least (as reflected by slenderness of body and general appendage attenuation). One can easily visualize that during Pleistocene pluvial conditions the montane forests, with their litter fauna, moved to lower elevations. El Sótano de Yerbaniz, habitat of *T. elliotti*, lies at an elevation of 242 m in the Sierra de El Abra of Tamaulipas and San Luis Potosí and very near to the high elevation Sierra de Guatemala of Tamaulipas. The caves inhabited by *T. rhodesi* and *T. reddelli* lie, respectively, at elevations of 1527 m and about 1400 m. Consequently, the ancestor of *T. elliotti* could have been isolated the soonest as warming and drying caused upward move-

ment of the montane forests and their litter species. [See also Mitchell and Kawakatsu (1972) for a discussion of the possible relationships between Pleistocene climatic fluctuations and the distribution of cave and epigean planarians in the Sierra de Guatemala.] Ancestors of *T. rhodesi* and *T. reddelli* certainly could have colonized their respective caves as soon, or sooner, than the ancestor of *T. elliotti*. Because their habitats are at much higher elevations than that of *T. elliotti*, however, isolation from the parental stock probably occurred at a later date. Thus, divergence from the ancestral species and adaptation to the cave environment in *T. rhodesi* and *T. reddelli* would not have proceeded to the extent seen in *T. elliotti*.

In closing, we suggest that *T. sylvestris* is not likely a cave species accidentally discovered in litter. Although the Sistema Montañoso Poblano Oaxaqueño is principally limestone, there are no known caves, karst landscapes, nor limestone outcrops near the locality where the scorpion was collected.

ACKNOWLEDGEMENTS

Field work was supported in part by a National Research Council of Canada operating grant in insect systematics and biogeography to Henry F. Howden and Stewart B. Peck. We wish to thank Oscar Francke for his thorough reading of the manuscript.

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OBSERVATIONS ON THE USE OF MEASUREMENTS IN THE SYSTEMATIC STUDY OF *LEIOBUNUM* (ARACHNIDA: PHALANGIDA)

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ABSTRACT

The genus *Leiobunum* is widely distributed in the eastern United States and has been under investigation since Thomas Say described *L. vittatum* as the first North American species in 1821. Several species have been described by various workers since Say, but the characteristics used in describing them have often been highly variable and of little taxonomic value. Measurements such as total leg length and body length have been standard parts of species descriptions for many years. Such characters are often not definitive and may cause confusion and misidentification when derived from single specimens or small collections as has often been the case. The value of several measurements used in taxonomic descriptions of species of *Leiobunum* is evaluated in this paper, and the separation of two closely related species which have previously been collectively referred to as *L. politum* is demonstrated.

INTRODUCTION

Leiobunum politum (Figs. 1, 2 and 3) was described by Clarence M. Weed in 1889 from a specimen collected in Champaign County, Illinois. Weed's original diagnosis (1889:89) is as follows: "Male Body 5 mm long, 2.8 mm wide. Palpi 3.5 mm long. Legs: I, 25 mm, II, 51 mm, III, 26 mm, IV, 36 mm." The description of *L. politum* includes reddish brown coloration, no marking or faint indication of the central mark, a series of small, acute, black spines over each eye, slender palpi, some banding in coloration of the legs and a description of the shape of the penis.

Later descriptions of *L. politum* by Weed, and by a number of taxonomists who followed him, were based upon essentially the same taxonomic characters. The use of leg length became a regular part of species diagnoses, and characters such as coloration, marking, and spination became standard in descriptions and were included in the keys of some taxonomic papers. These characters are beneficial to a degree, but in descriptions of *Leiobunum* they are not always definitive.

The problem of variation in the species of *Leiobunum* was recognized early by Weed (1892a) in a paper dealing with variation in *L. vittatum* (Say). He states, "I conclude that we have to do with a very variable species, in which natural selection has increased the size of the body and length of the legs to the southward, and shortened them in the north." Further, "... the size of the body and length of legs varies greatly with the locality, as a rule the body becoming larger and the legs longer as we go southward." Measurements are presented to support his conclusion in the publication.

In an article published in the same year Weed (1892b) presented measurements of a male specimen which he believed to be *L. politum* collected in New Hampshire which are as follows: "Male 3.1 mm long, 2.4 mm wide; palpi 2.7 mm long. Legs: first 26 mm, second 48 mm, third 26 mm, fourth 37 mm." The rest of the description for the New Hampshire specimen is essentially the same as for the Illinois type specimen of *L. politum*. The New Hampshire specimen has shorter body length and pedipalp length than the specimen from Illinois, but leg length is essentially the same in both.

A year later Weed (1893c) published a description of a new subspecies, *L. politum magnum* Weed, from Mississippi which was based upon the following diagnosis: "Male body 5 mm long, 4 mm wide; palpi 3.8 mm long. Legs: first 40 mm, second 80 mm, third 40 mm, fourth 58mm." The primary difference between the Illinois type specimen and the subspecies from Mississippi is in leg length.

Other papers dealing with variation and subspeciation in *Leiobunum* have been published. For example, subspecies have been described for *L. vittatum* (Say), *L. ventricosum* (Wood), and *L. longipes* Weed, all of which have the same general distribution as *L. politum*. Some authors have recognized the subspecies designations, others have not. Bishop (1949) in a discussion of *L. politum* states, "In species common to both the north and south, the southern specimens have longer legs and, in the case of some forms, there is a well defined cline. We prefer to regard *L. politum* as a distinct species." Weed (1893a, 1893b) presents figures and graphs for *L. ventricosum* and *L. vittatum* which demonstrate a north-south cline for leg length. Included in the publication is a description of *L. vittatum dorsatum* as a northern "form" of *L. vittatum* and *L. ventricosum hyemale* as a geographic "race" of *L. ventricosum*. Most authors following Weed recognized the existence of geographic variation, but diagnoses, keys and descriptions continued to utilize single measurements rather than ranges and averages in species descriptions. The problems created by this method of numerical evaluation become apparent when dealing with highly variable characters such as leg length in keys and descriptions. This study attempts to point up the need for a change in methods of evaluation and description of *Leiobunum* species.

MATERIALS AND METHODS

Penis length, genital operculum length, total body length and femur I length are discussed in this paper. Other measurements may be of value in adding information about the species in descriptions, but will serve no useful purpose here. The map (Fig. 7) illustrates the sites in the eastern United States from which collections were taken. The bulk of the material studied was taken from an area which extends along the Appalachian Mountains from Maryland to northern Alabama. Additional museum collections extend the range southward to northern Florida and northward to Maine.

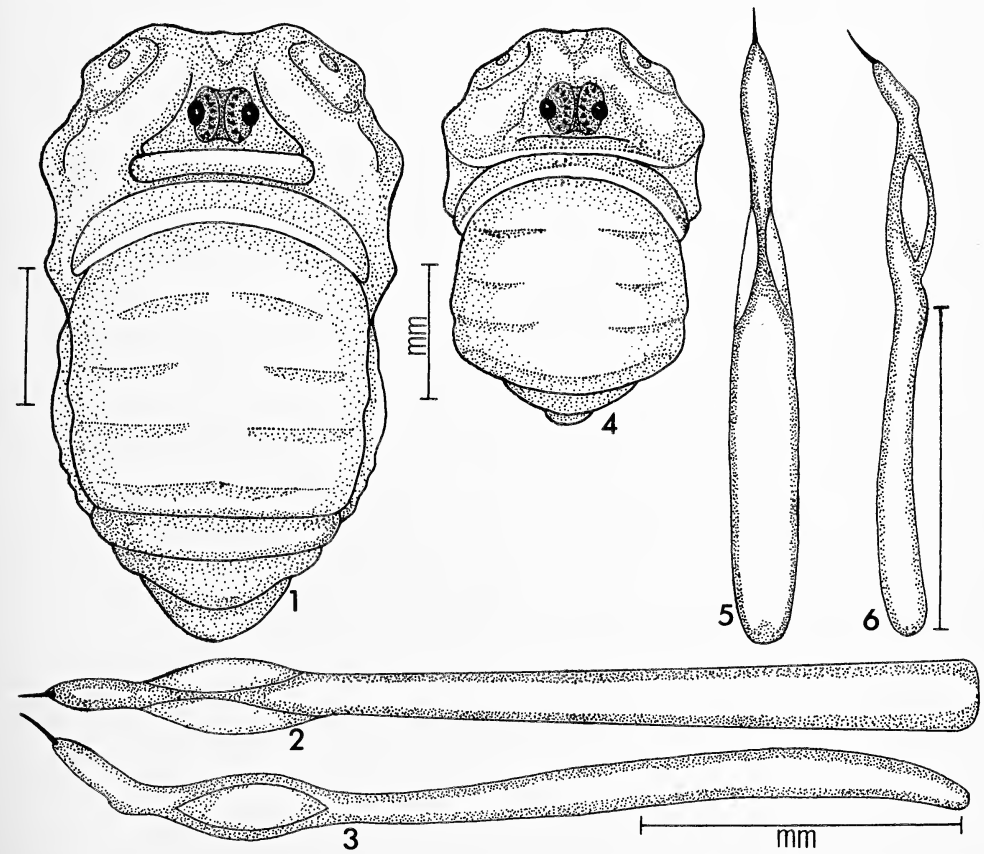
The graphs presented in the paper are analyses of collections of *L. politum* and *L. brachiololum* McGhee (Figs. 4, 5 and 6). Part of the series consists of specimens on loan from The American Museum of Natural History and part from collections assembled between 1967 and 1971 from the southeastern United States. The measurements were obtained from mature male specimens, most of which were collected during the months of July and August. Measurements were made using a Bausch and Lomb zoom dissection microscope calibrated to 0.1 mm. Each graph has been arranged with measurements proceeding from south (A) to north (U) so that clines will be indicated. The graphs indicate total range (horizontal bar), mean (vertical bar), and 2X standard error of mean

(box) for each sample over size 5. The number of specimens in each sample is indicated to the right of each horizontal bar and the total range of all samples is indicated at the top of the graph. Location of the sample site is indicated on the right side of each graph by letters corresponding to those on the map (Fig. 7). Total range for each species and area of overlap between species is indicated by vertical dotted lines.

RESULTS AND CONCLUSIONS

The penis of *Leiobunum* is an important species character which has been used very little in past descriptions. Each species has a distinctive penial form which has not been found to be subject to extensive variation from one geographic region to another as are leg length, coloration, marking, etc. Some authors described the penis and a few illustrated it, which is of considerable value in helping determine species in the absence of type specimens. The first to adequately illustrate the penes of United States species was N. W. Davis (1934), and S. C. Bishop (1949) also illustrated the penes of several species which he described from New York.

Figures 2 and 3 illustrate the penis of *L. politum* Weed and figures 5 and 6 the penis of *L. bracchiolum* McGhee. The general similarity between these two species is obvious, and *L. bracchiolum* has undoubtedly been described as *L. politum* through the years because of similarities in morphology, coloration, leg length, etc. Anyone observing the



Figs. 1-6.—*Leiobunum politum*: 1, dorsal view of male; 2, dorsal view of penis; 3, lateral view of penis. *L. bracchiolum*: 4, dorsal view of male; 5, dorsal view of penis; 6, lateral view of penis.

similarity between these species in the southern and northern states, while assuming that the cline which has been described for leg length holds true for all measurements, and without knowledge of the variances in different body dimensions would probably consider them to be geographic variants of the same species. The same conclusion might be drawn from using the illustrations of *L. politum* from earlier publications. There is evidence that some past descriptions of *L. politum* may have been derived from specimens of *L. brachiolum* as a result of the idea of a distinct north-south cline. Weed's New Hampshire description of *L. politum* may well have been a description of *L. brachiolum*. Several museum vials of *L. brachiolum* were labeled *L. politum*.

L. brachiolum was first discovered in a collection from Frederick Co., Maryland which is at about the same latitude as Weed's type locality for *L. politum* (Fig. 7). While

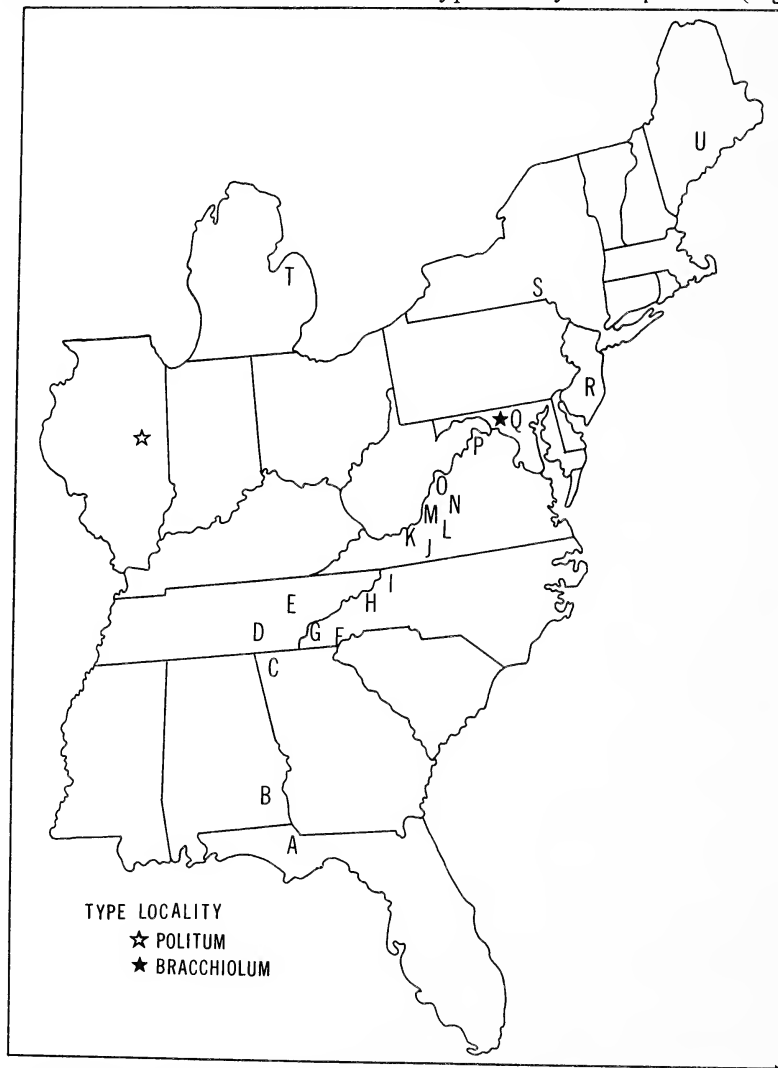


Fig. 7.—Distribution of *L. politum* and *L. brachiolum* specimens used in the study. Collecting sites from south to north include: Liberty Co., Florida (A); Barbour Co., Alabama (B); Dade Co., Georgia (C); Van Buren and Anderson Co., Tennessee (D & E); Transylvania, Graham, Yancey and Wilkes Co., North Carolina (F, G, H, I); Montgomery, Giles, Bedford, Craig, Rock Bridge, Bath and Warren Co., Virginia (J, K, L, M, N, O, P); Frederick Co., Maryland (Q); Bargaintown, New Jersey (R); Ithaca, New York (S); Huron, Michigan (T); and Orono, Maine (U).

identifying the specimens of the Maryland collection it became apparent that two distinct groups of phalangids seemed to fit the general description of *L. politum*. Additional specimens of *L. brachiolium* from farther south and the comparisons made during this study resulted in the recognition of *L. brachiolium* as a distinct species.

Figure 8 is a graph of the measurements of the penes of both species taken from 135 specimens in 24 collections. The samples are arranged in an approximate order from south (A) to north (U) so that any indication of a cline will be demonstrated. The following observations concerning penis length are apparent: (1) No evidence of a north-south cline is indicated in penis length for either species. In fact, the Warren Co., Virginia (P) and the Frederick Co., Maryland (Q) specimens are, on the average, slightly larger than the Liberty Co., Florida (A) specimens in *L. politum*. Specimens from northern Michigan (T) fall within the same range as specimens from Virginia (J-P), North Carolina

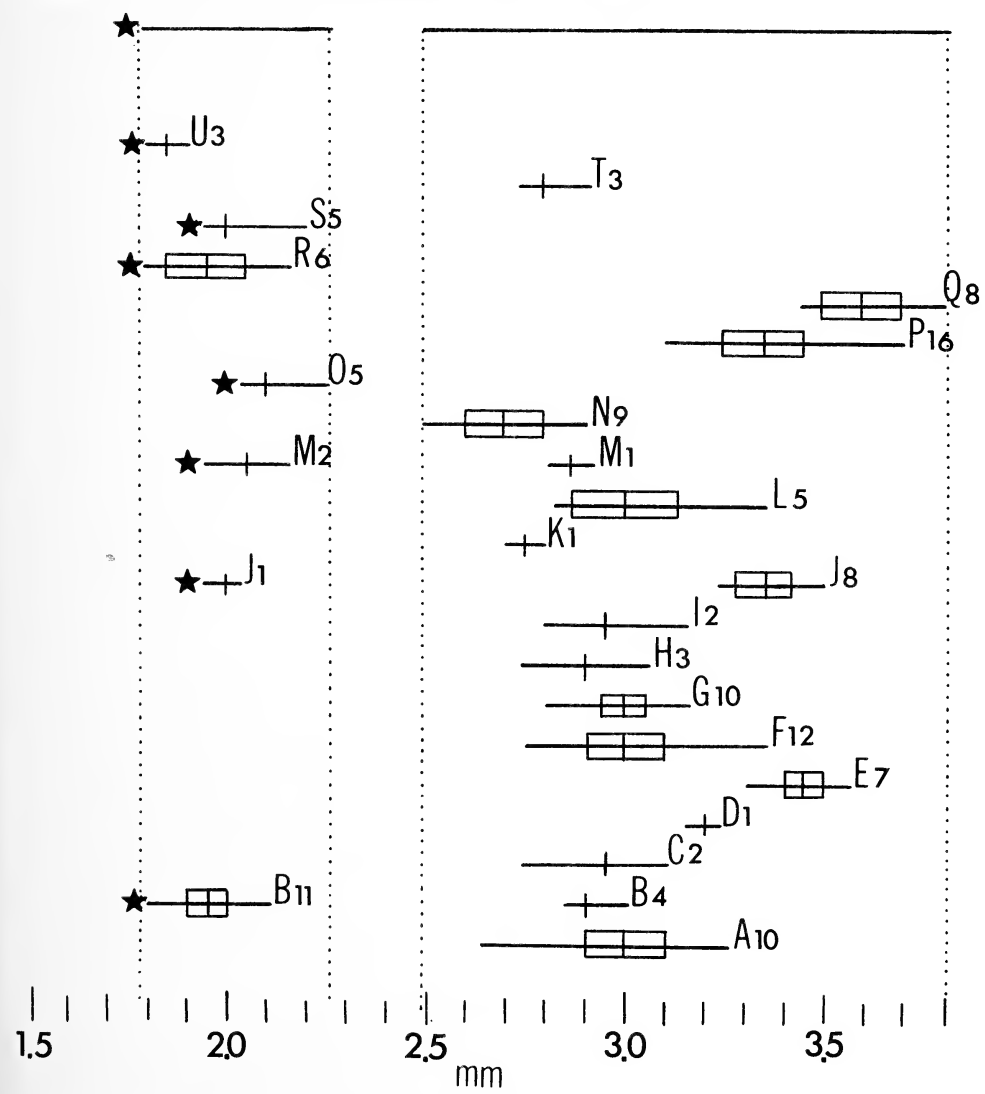


Fig. 8.—Graph illustrating the range, mean and 2X the standard error of the mean for penis length in *L. brachiolium* and *L. politum*. *L. brachiolium* populations indicated by stars. Total range for each species indicated by solid lines at the top of the graph.

(F-I), Tennessee (D-E), Georgia (C), Alabama (B), and Florida (A). (2) There are two distinct groups of ranges in penis length in which there is no overlap in size from Alabama to Maine. This cannot be attributed to seasonal variation, since all specimens were collected from July to August and it cannot be attributed to geographic variation, since both groups have almost identical ranges from the south to the north and often occur in the same area together. (3) The morphology (Figs. 3 and 5) of these two penial types remains relatively constant from south to north. The *L. politum* penis, with slight variations, has essentially the same appearance in Florida and Michigan specimens, and the *L. brachiolum* penis is virtually identical in appearance along its entire range from Alabama to Maine.

The use of penial morphology alone could be misleading in species identification, especially where small samples from widely separated geographic areas are used and where too much reliance is placed in the north-south "cline theory" as applied to leg length. It is obvious that two quite distinct species are indicated by both morphology and size of the penis in this case.

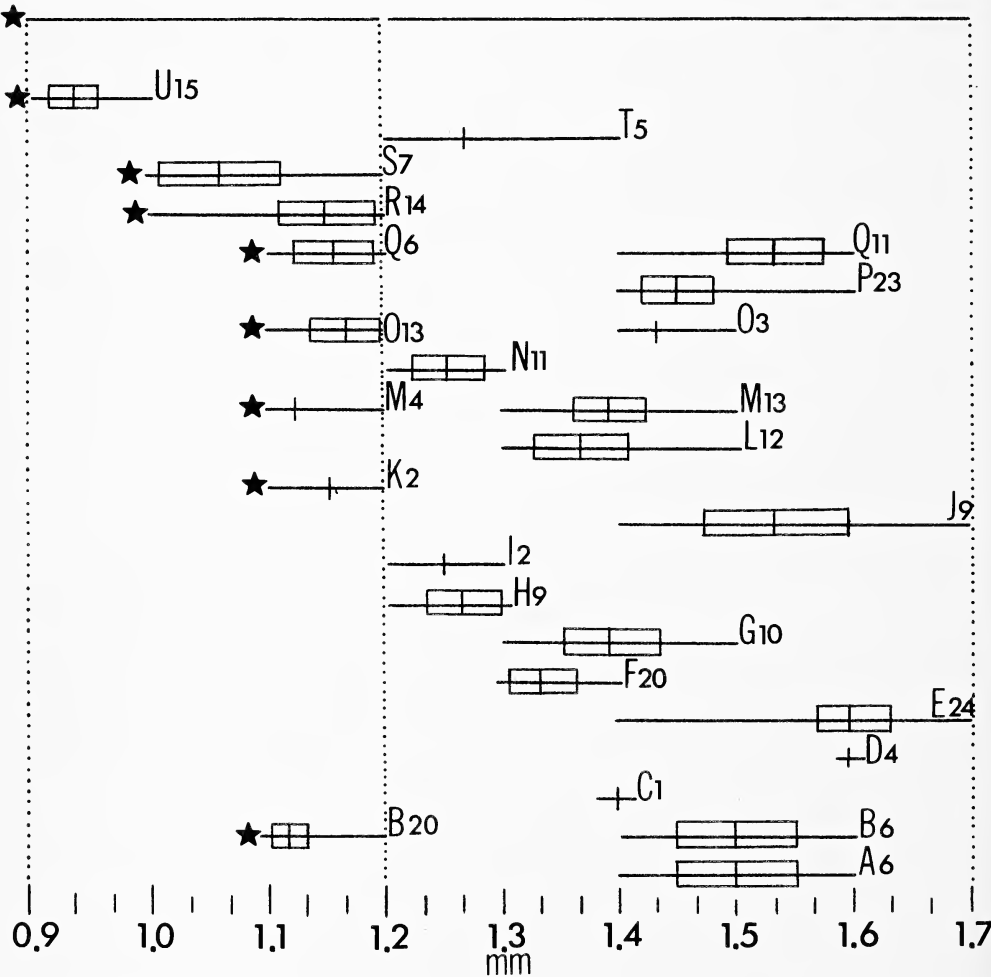


Fig. 9.—Graph illustrating the range, mean and 2x the standard error of the mean for genital operculum length in *L. brachiolum* and *L. politum*. *L. brachiolum* populations indicated by stars. Total range for each species indicated by solid lines at the top of the graph.

Figure 9 illustrates the length of the genital operculum of males of *L. politum* and *L. brachiolum*. The following observations may be drawn from the graph: (1) The length of the genital operculum shows no clear indication of a north-south cline in either species, (2) the length of the operculum is of relatively constant size as compared to leg length (Fig. 11) and total body length (Fig. 10) throughout the entire range of the species, but is more variable than penis length (Fig. 8). (3) There is a rather clear line of demarcation between the ranges of operculum size in the two species and no overlap exists in the standard errors of the means from south to north. The length of the genital operculum in these species clearly demonstrates that variations of all body regions do not correspond to variations in leg length.

Figure 10 demonstrates the total body length of approximately 256 male specimens from 26 collections ranging from Florida to Maine. The following observations may be drawn from the graph: (1) There is little or no indication of a north-south cline in body length for either species. The specimens from Anderson Co., Tennessee (E) and Frederick Co., Maryland (Q) tend to be slightly larger than the Florida (A) and Alabama (B)

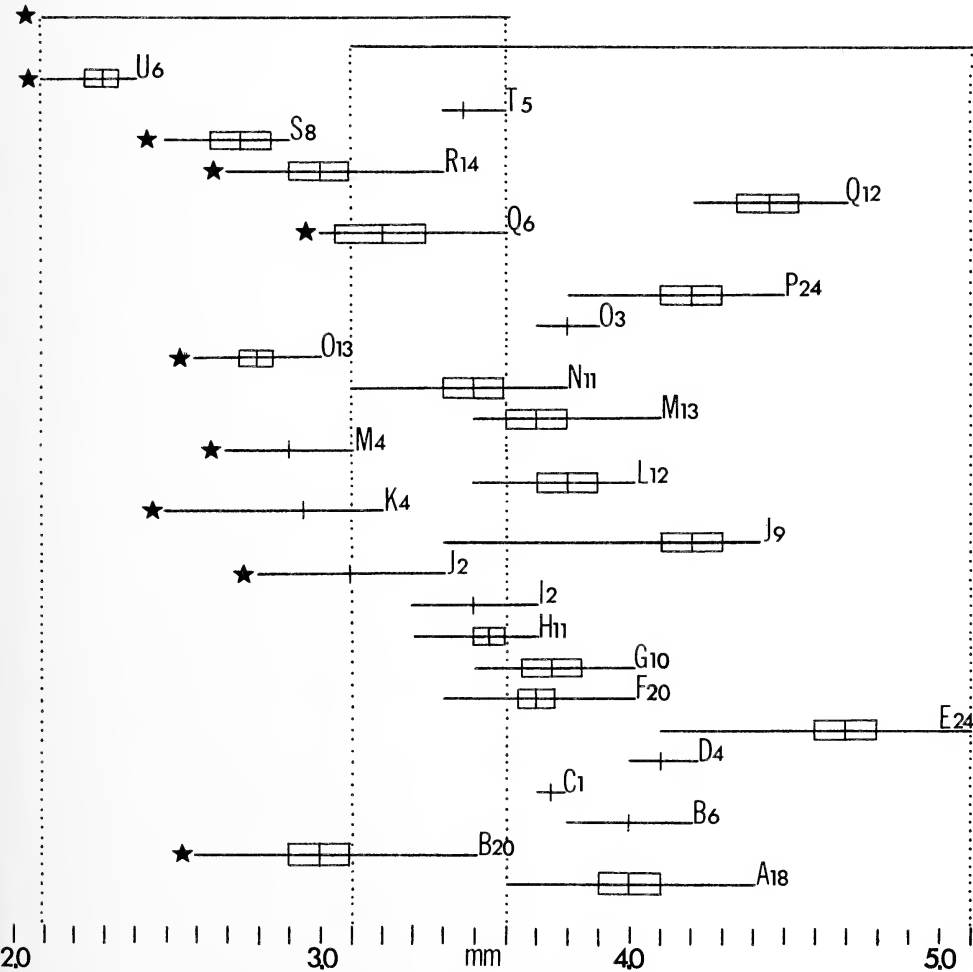


Fig. 10.—Graph illustrating the range, mean and 2x the standard error of the mean for total body length in *L. brachiolum* and *L. politum*. *L. brachiolum* populations indicated by stars. Total range for each species indicated by solid lines at the top of the graph.

specimens. The ranges and means for specimens from North Carolina (F-I), Virginia (J-P) and Michigan (T) tend to correspond for the most part. (2) Two distinct ranges of total length are indicated by the measurements, although, the distinction is not as clearly defined as in penial and genital operculum length. The larger specimens of *L. brachiolum* overlap the smaller specimens of *L. politum* in a small percentage of cases, but there is no overlap in the standard errors of the means.

The graphs (Fig. 10 and 11) demonstrate little correlation between leg length and body length from south to north in these species. The legs become considerably shortened to the north but body length varies only slightly and on a more irregular basis. This seems to refute earlier ideas of a corresponding increase in leg length and body length toward the southern part of the range. It is also evident that, whereas, leg length gives no indication of two species, body length indicates this when sufficient numbers of samples and specimens are available from the species range. The use of single measurements taken from small samples is obviously of little value.

In surveying the taxonomic literature concerned with *Leiobunum* one becomes immediately aware of the extensive use of total leg length as a primary part of species descriptions. Of the numerous characters which were measured during the course of this study, leg length is by far the most variable. In addition to the extreme variability in leg

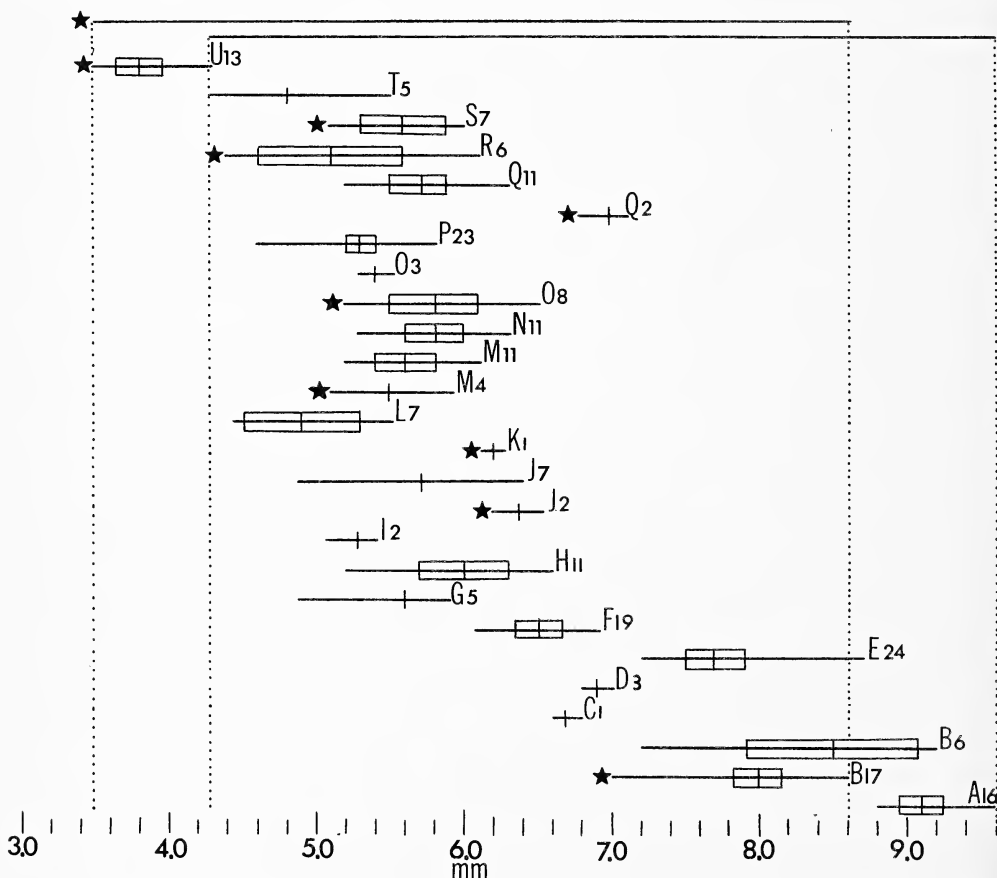


Fig. 11.—Graph illustrating the range, mean and $2 \times$ the standard error of the mean for femur I length in *L. brachiolum* and *L. politum*. *L. brachiolum* populations indicated by stars. Total range for each species indicated by solid lines at the top of the graph.

length, it is one of the most difficult measurements to obtain because of the tendency for legs to be broken and lost during capture or while in preservation.

In this study the length of the femur of the first pair of legs has been utilized to demonstrate the variation in leg length. The ratio of total length of the legs to individual segments has been found to be fairly consistent from specimen to specimen in species which have been studied. It is, therefore, easier to obtain information regarding variation in leg length from the measurement of a femur on one leg than to measure the total length of all legs.

Figure 11 is a graph representing the range, mean and $2\times$ the standard error of the mean of 26 collections containing 225 male specimens from Florida to Maine. The following observations may be drawn from the graph: (1) Leg length is highly variable as compared with other measureable characters both within samples and between the southern and northern samples. (2) a cline exists in the length of the legs of both *L. politum* and *L. brachiolum*, in which the legs become progressively longer from the north toward the south, (3) there is very little difference between the length of the legs in *L. politum* and *L. brachiolum* over their range, and the species cannot be distinguished on the basis of this character, (4) there is a well defined break in the ranges of leg length between the Anderson Co., Tennessee (E) and the Transylvania Co., North Carolina (F) specimens of *L. politum*. This has (as previously indicated) been interpreted as evidence of subspeciation on the basis of leg length.

Leg length represents one of the weakest measurable taxonomic characters available in the study of *Leiobunum*. The inclusion of these measurements in descriptions may serve to add to the overall assessment of a species, but in order for them to be of value an understanding of the degree of variation from one geographic region to another must be gained. This character is of little use in diagnoses and keys as a single measurement taken from only a few specimens as it has been employed in the past in species descriptions.

An attempt has been made to demonstrate the value of using certain measurements as additional criteria in the descriptions of *Leiobunum* species. It has been shown that measurements can be beneficial if used correctly. Descriptions of characters such as the penis and pedipalp are essential in species determinations, but the use of these characters has been restricted and replaced with descriptions of leg length, color, markings and spination which are of limited or no value in keys and diagnoses of species. Such characters have been misleading and confusing in the taxonomy of this group of phalangids.

The study has shown that a cline exists from south to north in leg length as suggested by earlier workers, but that it is not as apparent or does not exist in other measureable characters. The cline theory has, therefore, caused misidentification of specimens in the past because it has been assumed that other body parts followed the variance and clinal characteristics of leg length, which is not the case. It has also been demonstrated that the concept of subspeciation in *Leiobunum* is vague and that leg length, which has been the primary consideration in describing subspecies, is probably the least reliable of all characters to use.

The conclusions arrived at in this paper are based upon observations derived from two closely related species. Similar measurements and comparisons have been made for several other species of *Leiobunum* which indicate that the same conclusions may hold true for other members of the genus with similar distributions.

ACKNOWLEDGEMENTS

My thanks to Dr. Perry C. Holt, Professor of Biology at Virginia Polytechnic Institute and State University for his suggestions during the preparation of this paper, and to Dr. Clay M. Chandler, Professor of Biology at Middle Tennessee State University for reviewing the manuscript. The American Museum of Natural History loaned part of the material used in the study and Middle Tennessee State University provided a grant which aided in the collection of specimens from Alabama and Florida.

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RESEARCH NOTES

A NEW *OTIOTHOPS* FROM COLOMBIA (ARANEAE, PALPIMANIDAE)

Through the courtesy of Mr. John A. Kochalka of the University of Vermont, I have recently had the opportunity to examine specimens of a new species of the *oblongus* group of *Otiothops* from the foothills of the Sierra Nevada de Santa Marta, Colombia. Only three members of the *oblongus* group were previously known: *O. oblongus* Simon from Venezuela, Trinidad, and Guyana, *O. intortus* Platnick from Trinidad, and *O. whitticki* Mello-Leitao from Guyana and now newly recorded from Surinam (Benzdorp, Lawa River, Marowijne District, 6 November 1963, B. Malkin, one male in the American Museum of Natural History). The new species is the first known American palpimanid possessing a modified cymbium (Fig. 1). The illustrations are by Dr. Mohammad U. Shadab.

Otiothops kochalkai, new species

Types.—Male holotype and female paratype from disturbed semideciduous forest between San Pablo and San Pedro, Magdalena, Colombia (male, elevation 1000 feet, 4 February 1974; female, elevation 2200 feet, 3 February 1974; J. A. Kochalka), deposited in the American Museum of Natural History.

Etymology.—The specific name is a patronym in honor of the collector of the type specimens.

Diagnosis.—*Otiothops kochalkai* may be easily distinguished from the other known American palpimanids by the prolaterally bent tip of the cymbium (Fig. 1) and anteriorly expanded spermathecae (Fig. 2).

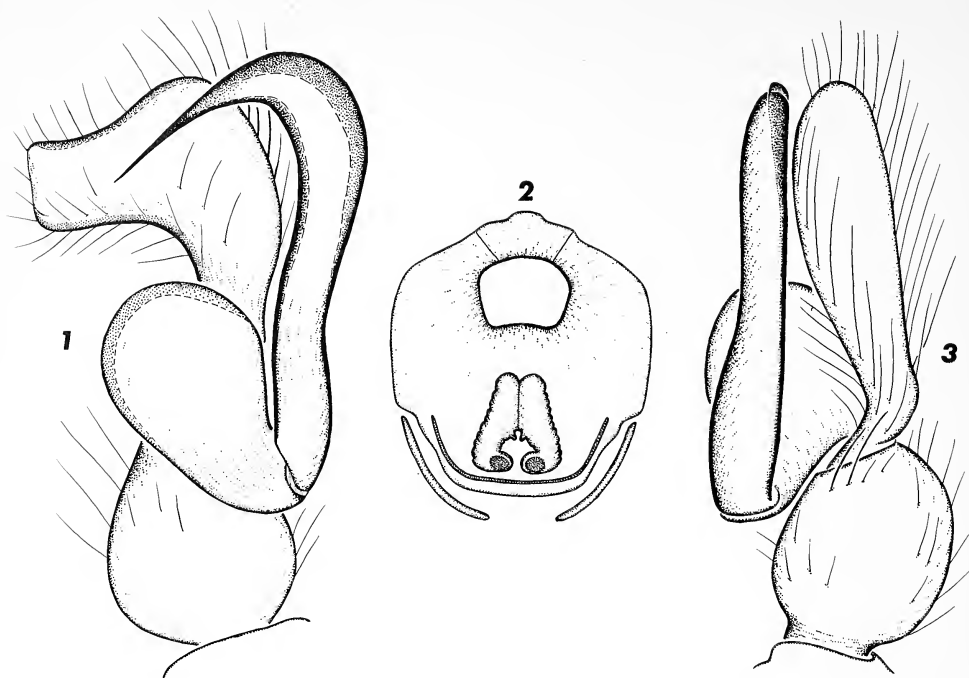
Male.—Total length 3.67 mm. Carapace 1.65 mm long, 1.19 mm wide. Femur I 1.08 mm long, 0.48 mm high (holotype). Cephalic area sharply elevated. Posterior median eyes contiguous. Embolus situated retrolaterally, bent prolaterally at tip, with thin distal flange; cymbium sinuous, bent prolaterally at tip (Figs. 1, 3).

Female.—Total length 7.38 mm. Carapace 3.35 mm long, 2.45 mm wide. Femur I 2.38 mm long, 1.06 mm high (paratype). Cephalic area sharply elevated. Posterior median eyes separated by slightly less than half their diameter. Abdominal scutum with two posterior paramedian sclerotized strips; spermathecae much wider anteriorly than posteriorly (Fig. 2).

Material Examined.—Only the types.

NOMENCLATURE

I have recently noted that the family-group name Otiothopoidae, established by Thorell in 1869 in a one sentence statement in his volume "On European Spiders" (p. 43), antedates both my own subfamily name Otiothopinae and the family name



Figs. 1-3.—*Otiothops kochalkai*, new species: 1, palp, ventral view; 2, vulva, dorsal view; 3, palp, retrolateral view.

Palpimanidae. As Thorell's name has never been used, it should presumably be suppressed under Article 79b of the International Code of Zoological Nomenclature. **Norman I. Platnick**, Department of Entomology, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

A NEW *SCOPODES* FROM CALIFORNIA (ARANEAE, GNAPHOSIDAE)

Recent sorting of accumulated material at the American Museum of Natural History has revealed a specimen of an undescribed *Scopodes* from Tulare County, California; this is the fifth species of the genus known from California. The specimen, a male, will key out to *Scopodes catharius* in the published key (Platnick and Shadab, 1976, p. 17) but may be easily distinguished from that species by its sinuous embolus, twisted conductor, subapically invaginated median apophysis, and broad retrolateral tibial apophysis (Figs. 1, 2). The phylogenetic relationships of the species cannot be determined with any degree of certainty until the female is discovered. The combined presence of a palpal conductor situated beside the median apophysis and a denticle on the cheliceral retromargin indicate that the species probably belongs to the clade including *Scopodes kastoni* and *S. catharius* (Platnick, N. I., and M. U. Shadab 1976. Amer. Mus. Novitates 2594: 1-33, fig. 39).

However, since the presence of a palpal conductor is a plesiomorphic character in *Scopodes* (as determined by out-group comparison with *Zimiromus*), the possibility cannot be ruled out that the species represents the most primitive member of the *ochraceus* group instead. The illustrations are by Dr. Mohammad U. Shadab.

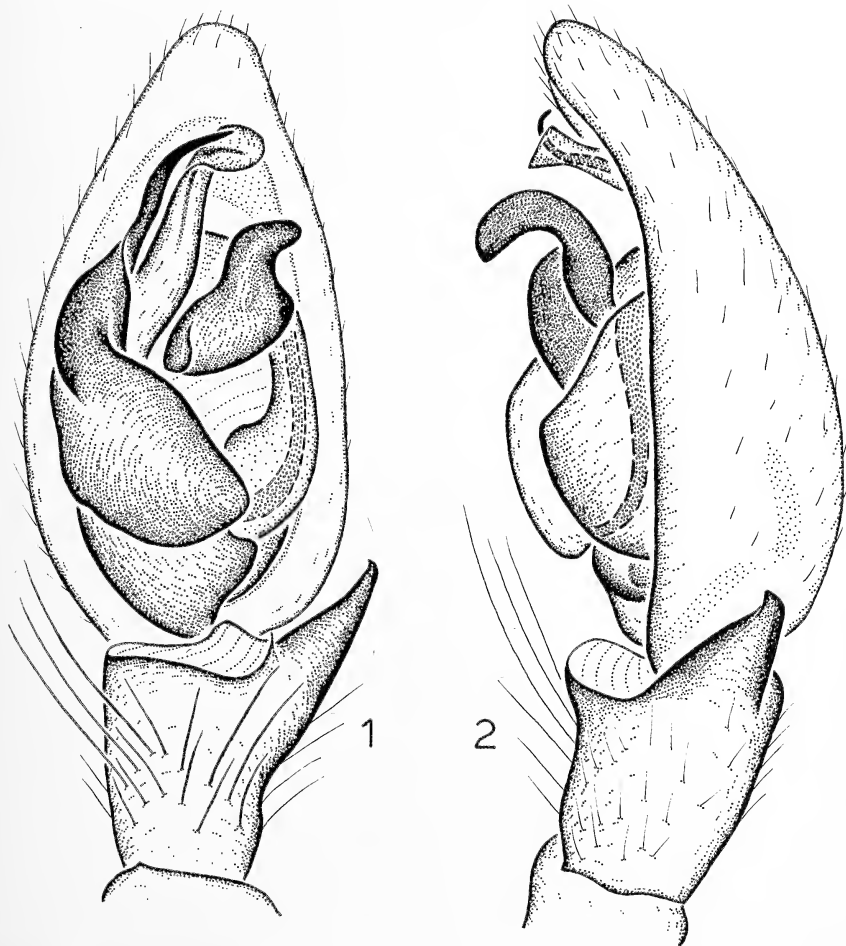
Scopodes gertschi, new species

Type.—Male holotype from Kawea River, 5 miles east of Three Rivers, elevation 1258 feet, Tulare County, California (17 July 1952; W. J. Gertsch), deposited in the American Museum of Natural History.

Etymology.—The specific name is a patronym in honor of the collector of the holotype.

Diagnosis.—*Scopodes gertschi* may be distinguished from the other known species of the genus by the wide and sinuous embolus and the subapically invaginated median apophysis (Fig. 1).

Male.—Total length 5.51 mm. Carapace 2.44 mm long, 1.84 mm wide. Femur II 2.12 mm long (holotype). Eye sizes and interdistances (mm): AME 0.10, ALE 0.12, PME 0.13,



Figs. 1-2.—*Scopodes gertschi*, new species: 1, palpus, ventral view; 2, palpus, retrolateral view.

PLE 0.12; AME-AME 0.06, AME-ALE 0.04, PME-PME 0.05, PME-PLE 0.09, ALE-PLE 0.04. Median ocular quadrangle length 0.31 mm, front width 0.25 mm, back width 0.21 mm. Twisted palpal conductor beside heavy, sharply bent embolus (Fig. 1). Retrolateral tibial apophysis broad, relatively massive (Fig. 2). Leg spination: tibiae: III r1-1-1; IV r2-1-1; metatarsus I vlp-0-0.

Female.—Unknown.

Distribution.—Known only from the type locality. This is the most northern record of *Scopodes* in California, and is approximately 40 miles west of the next most northerly collecting site (1-2 miles west of Lone Pine, Inyo County). Since *Scopodes naturalisticum* has been taken much farther north in Nevada, it is possible that additional California species will be found in the Fresno area and further north. Norman I. Platnick, Department of Entomology, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024.

A NEW *MICROSA* FROM THE BAHAMA ISLANDS (ARANEAE, GNAPHOSIDAE)

Since the discovery of *Microsa chickeringi* on St. Thomas (Platnick and Shadab, 1977), additional specimens have been found from two other of the Virgin Islands and, more importantly, an additional species, described below, has been found from the Bahama Islands. Since the closest relatives of *Microsa* Platnick and Shadab, appear to be African (*Asemesthes* Simon), the first species could have been regarded as an undescribed form introduced into the West Indies by man, but the discovery of a second species confirms the status of the genus as a native element of the West Indian spider fauna and suggests that additional species will eventually be found to occur on other islands of at least the Greater Antilles.

All specimens cited below are in the American Museum of Natural History. The format of the descriptions follows those in Platnick and Shadab (1975). The illustrations are by Dr. M. U. Shadab.

Microsa chickeringi Platnick and Shadab

Microsa chickeringi Platnick and Shadab, 1977: 193, figs. 1-9.

New records.—British Virgin Islands: Virgin Gorda; Baths and Devil's Bay (25 June 1966), 1 female. United States Virgin Islands: St. John; King Hill, Coral Bay, Berlese sample of leaf litter (18 July 1975; W. B. Muchmore), 1 male, 1 female.

Microsa gertschi, new species Figures 1-4

Types.—Male holotype and female paratype from South Bimini, Bahama Islands (May 1951; W. J. Gertsch), deposited in the American Museum of Natural History.

Etymology.—The specific name is a patronym in honor of the collector of the type specimens.

Diagnosis.—Males of *M. gertschi* may be distinguished from those of *M. chickeringi* by the much larger prolateral tegular apophysis (Fig. 1), females by the much more widely separated lateral spermathecal lobes (Figs. 3, 4).

Male.—Total length 1.91 mm. Carapace 0.92 mm long, 0.83 mm wide. Femur II 0.61 mm long (holotype). Eye sizes and interdistances (mm): AME 0.03, ALE 0.05, PME 0.04, PLE 0.06; AME-AME 0.04, AME-ALE 0.05, PME-PME 0.05, PME-PLE 0.08, ALE-PLE 0.07. MOQ length 0.13 mm, front width 0.10 mm, back width 0.12 mm. Palp with large prolateral tegular apophysis (Fig. 1), without retrolateral tibial apophysis (Fig. 2). Leg spination: tibiae: I v1r-2-0; II v1r-1r-1p; III p1-1-1, v1p-2-2; IV p1-1-1, v2-2-2; metatarsi: I, II v2-0-2; III p0-0-2, v2-0-2, r0-0-2; IV v1p-1p-2.

Female.—Total length 2.20-2.99 mm. Carapace 0.97-1.19 mm long, 0.84-0.93 mm wide. Femur II 0.60-0.72 mm long (nine specimens). Eye sizes and interdistances (mm): AME 0.03, ALE 0.05, PME 0.03, PLE 0.05; AME-AME 0.04, AME-ALE 0.03, PME-PME 0.06, PME-PLE 0.06, ALE-PLE 0.11. MOQ length 0.14 mm, front width 0.10 mm, back width 0.12 mm. Epigynum with anterior ridge (Fig. 3), spermathecae with widely separated lateral lobes (Fig. 4). Leg spination: femora: II p0-0-0; IV p0-0-0; tibiae: I v1r-2-1p; II v1r-1r-2; III p1-1-1, v1p-2-2; IV v1p-2-2; metatarsi: I, II v2-0-2; III v1r-2-2, r0-0-2; IV v1p-1p-0.

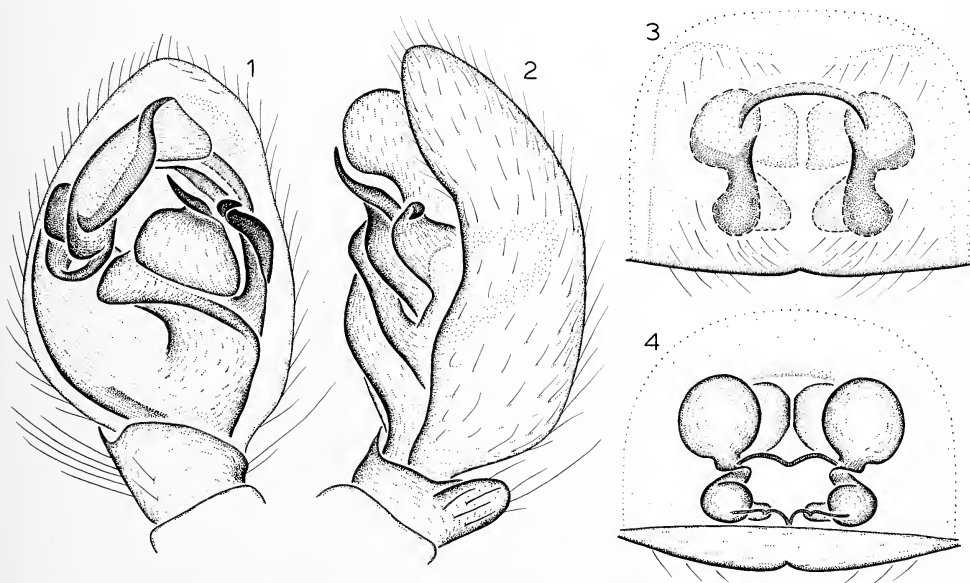
Material Examined.—Eight females taken with the types.

Distribution.—Known only from the Bahama Islands.

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Figs. 1-4.—*Microsa gertschi*, new species: 1, palp, ventral view; 2, palp, retrolateral view; 3, epigynum, ventral view; 4, vulva, dorsal view.

COMMENTS ON A LIZARD EATING *ARGIOPE*
(ARANEIDAE:ARANEAE)

Recorded occurrences of orb-weaving spiders preying on vertebrates are rare. Bristowe (The Comity of Spiders, Volume II, The Ray Society, London, Number 128, 1941, p. 330) cites observations of lizards falling prey to Argiopidae (=Araneidae) but no specifics are given in his account. The present note confirms and extends knowledge of lizards preyed upon by orb-weavers.

On August 28, 1976, I observed a female *Argiope aurantia* that had killed and was wrapping a juvenile broad-headed skink, *Eumeces laticeps* (family Scincidae). The web was constructed between a tree limb and the bottom side of an old wooden bridge over Mud Creek, 10 km N, 7 km E of Oscar, Jefferson County, Oklahoma. The lizard presumably came into contact with the web while climbing either the limb or bridge where the web was attached. Collins (Complete Field Guide to American Wildlife: East, Central and North. Harper and Brothers, Publishers, New York, 1959, pp.373) reports that *Eumeces laticeps* is partially arboreal. Since the web was intact, it can be assumed the lizard was not actively seeking a meal of the spider, but rather that the spider attacked the lizard. The *Eumeces* (35.6 mm snout-vent length) received three bites which penetrated the body. One bite was in the center of the dorsum 5.1 mm anterior to the origin of the hind limbs, the second was on the tail 30.0 mm from the tip, and the third was on the right forelimb at the junction of the ulna and humerus. The bite on the back was positioned in a manner suggesting the spider attacked from the side (i.e., the two fang holes were along the mid-dorsal stripe with one hole anterior to the other). The actual sequence of bites was not observed, but probably the bite on the back was first. The genus *Eumeces* is notorious for losing its tail to elude predators, and therefore the tail probably would have been missing if it were bit first. The toxin apparently worked quickly, because the spider and web showed no signs of a struggle.

The manner in which *Argiope* wrap paralyzed lizards has received no mention in the literature. The present *A. aurantia* carried the lizard to the center of the web and folded the lizard in a workable-sized packet prior to wrapping. The lizard's head was bent to the right at the pectoral girdle, the tail was looped up on the left side of the body to the forelimb, and then back down along the basal part of the tail.

Both the *Argiope* and the *Eumeces* are deposited in the Midwestern State University Invertebrate collection. James Cokendolpher, Department of Biology, Midwestern State University, Wichita Falls, Texas 76308.

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Cover illustration, *Pseudogarypus bicornis* (Banks), by Susan Lindstedt

Printed by the Speleo Press, Austin, Texas

Posted at Warrensburg, Missouri, U.S.A., February, 1978

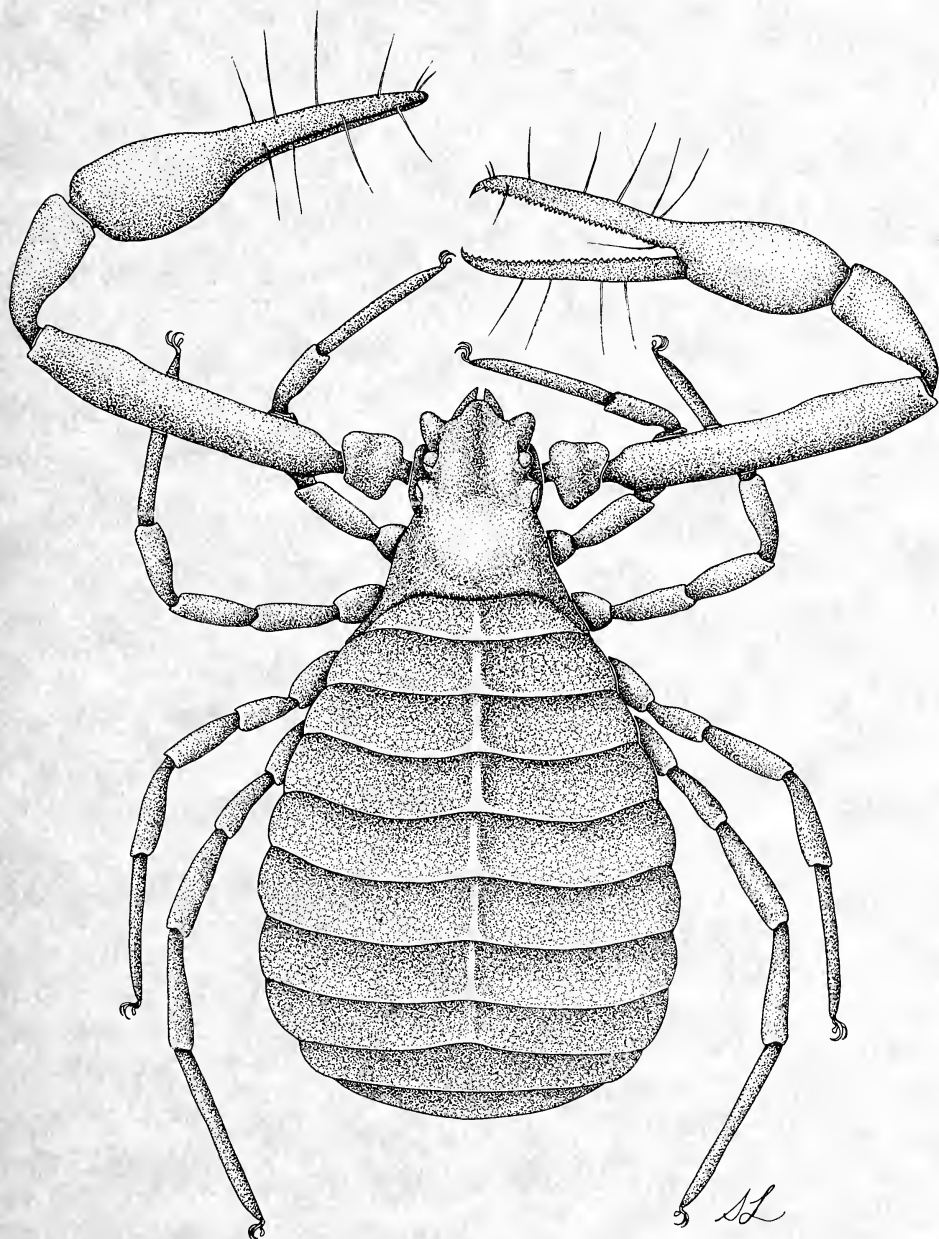
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The Journal of ARACHNOLOGY

OFFICIAL ORGAN OF THE AMERICAN ARACHNOLOGICAL SOCIETY



VOLUME 5

FALL 1977

NUMBER 3

THE JOURNAL OF ARACHNOLOGY

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Manuscripts for *The Journal of Arachnology* are acceptable from members of the Society, for whom there are no page charges. Manuscripts must be typewritten double or triple spaced on 8.5 in. by 11 in. bond paper with ample margins, and may be written in the following languages: English, French, Portuguese, and Spanish. Contributions dealing exclusively with any of the orders of Arachnida, excluding Acari, will be considered for publication. Papers of a comparative nature dealing with chelicerates in general, and directly relevant to the Arachnida are also acceptable. Detailed instructions for the preparation of manuscripts appear in the Fall issue of each year, and can also be obtained from the Editor. Manuscripts that do not follow those instructions will be returned to the author(s) without the benefit of review. Manuscripts and all related correspondence must be sent to Dr. Oscar F. Francke, Editor, Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409, U. S. A.

AN ANALYSIS OF ALTERNATIVE MATING TACTICS OF THE JUMPING SPIDER *PHIDIPPUS JOHNSONI* (ARANEAE, SALTICIDAE)

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ABSTRACT

Phidippus Johnsoni males employ three different mating tactics. The one used depends on the type of female that the male encounters. With adult females outside nests, they use type 1 courtship, which is a form of visual communication and includes displays such as dancing and posturing. Similar courtship has been described for many salticid species. With adult females inside nests, males use type 2 courtship, which is a form of non-visual communication and includes elements such as probing and vibrating of the nest. This type of courtship is similar to that of some web-building spiders, and behavior of this type has generally received little attention in previous studies of salticid behavior. When pursuing subadult females inside nests, males use type 2 courtship followed by cohabitation. Postmount courtship is a non-visual phase that precedes copulation and occurs as a component of each tactic. The different types of courtship involve distinctly different motor patterns. In addition to male courtship signals, there are other signals performed primarily by females and subadults and some that occur primarily during aggressive interactions between males. The total number of major signals for this species is estimated as 24. Some of these occur only infrequently. The sequence of events during interactions between spiders tends to be complex.

INTRODUCTION

Courtship will be defined as heterosexual communicatory behavior that forms the normal preliminaries to mating. This definition combines and modifies those of Manning (1972) and Morris (1956). Courtship and the associated behavior of the male of a species will be viewed as an "adaptive strategy" related to mating (Slobodkin and Rapoport 1974). The mating strategy of the salticid spider *Phidippus johnsoni* Peckham and Peckham is more complex than that normally associated with spiders and most animals. Each individual male of this species has at his disposal three distinct tactics and two distinct types of courtship. The mating tactic that the male uses depends on the type of female he encounters and her location.

1. If the male encounters an adult female that is outside her nest, he employs visual courtship ("type 1"), consistent with the general portrayal of salticid courtship (Crane 1949b) and the highly developed visual system of spiders in this family (Land 1972).
2. If the male encounters an adult female inside her nest, he employs a different type of courtship ("type 2"), which is a form of non-visual communication. The nest (retreat) is a

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silk structure that these diurnal spiders construct under rocks and in other similar locations. They remain inside nests at night, during inclement weather, and during molting. Females oviposit inside nests and remain in their nests with the eggs. When mating follows type 2 courtship, it occurs inside the nest. Although suggestive observations have been reported, to my knowledge it has not been previously reported that a salticid species has a non-visual courtship pattern associated with mating in nests. The reasons behind the relative neglect of this type of courtship in salticids are not altogether clear, although the fact that most observations have been made in the laboratory under conditions in which nests were not present is part of the explanation. In other cases, however, behavior apparently quite similar to *P. johnsoni* type 2 courtship was seen, but for some reason the authors chose not to refer to it as courtship. The observations of these authors will be returned to later, since they suggest that nest associated and non-visual courtship may be relatively widespread in the Salticidae.

3. If the male encounters a subadult female inside a nest, he first courts using type 2 courtship. Later he constructs a second chamber on the female's nest and cohabits with her until she molts, at which time he mates with the mature female inside the nest. "Mating" is used here as a synonym for "copulating."

Relatively many elements of behavior, with probable communicatory functions, are associated with each tactic. Both types of courtship generally begin with the individuals involved not in physical contact. However, after the male mounts the female, there follows a phase of courtship, common to both types and referred to as postmount courtship, during which the spiders are in physical contact.

Evidence concerning the sensory modalities employed in the two types of courtship was reported elsewhere (Jackson 1977). This paper will deal with the motor patterns involved in the mating strategy of this species. Individual elements of behavior will be described, and the sequence of behavior during interactions between spiders will be discussed. The goal is to document the complexity of the mating strategy of this species and the degree to which the differing tactics are distinct with respect to the motor patterns employed. Behavior of males and females will be contrasted, and male-female interactions will be compared with other types of interactions (male-male, male-subadult, etc.) in order to gain insights concerning the functions of the various motor patterns.

Among spiders there is a diversity of courtship behavior surpassed by few other animal groups (see Platnick 1971, for a recent review). This includes communication by tactile, auditory, olfactory, and chemotactic modes. Although vision may be important in the courtship of some species of Oxyopidae, Sparassidae, and Thomisidae (Clyne 1971, Coleman 1938, Dondale 1964, 1967, Whitcomb and Eason 1965), vision seems to be of minor importance for most groups of spiders. There are two notable exceptions, the Lycosidae (Rovner 1968) and the Salticidae, in which visual courtship is highly developed. Displays in these species include leg, palp, and abdomen movement, postures and dances, and similar behavior. Striking secondary sexual characteristics, such as tufts of hairs or pigmented scales, often become especially conspicuous during displays. In general, vision is more acute and displays are more elaborate in the salticids than in the lycosids. In fact, the salticids have one of the most highly developed invertebrate visual systems, which includes form vision, color vision, possible discrimination of the plane of polarization of light, and a resolving power on the order of 10 minutes of arc (DeVoe 1975, DeVoe and Zvargulis 1967, Eakin and Brandenburger 1971, Homann 1928, Kaestner 1950, Land 1972, Peckham and Peckham 1894, Yamashita and Tateda 1976).

The classic studies of salticid courtship were those of Peckham and Peckham (1889, 1890, 1894, 1909) and those of Crane (1948, 1949a, 1949b). The Peckhams described the courtship displays of many North American species, including some *Phidippus* but not *P. johnsoni*. They were especially interested in questions related to sexual selection. Generating considerable controversy, theirs were the first major studies of spider courtship. Working with a number of neotropical species in Venezuela, Crane was especially interested in innate releasing mechanisms in courtship behavior. From these works, plus those of many others (Baily 1968, Berland 1914, 1923, 1927, Bhattacharya 1936, Bonnet 1933, Bristowe 1929, 1931, 1941, 1958, Cloudsley-Thompson 1949, Davis 1974, Dewey 1965, Drees 1952, Edwards 1975, Emerton 1909, 1926, Forster and Forster 1973, Gardner 1965, Gerhardt 1921, 1923, 1924, Griswold 1977, Heil 1936, Homann 1928, Horner and Starks 1972, Kaston 1936, 1948, Legendre and Llinares 1970, Lockett 1939, McKeown 1936, Monterossa 1924, Montgomery 1910, Nielsen 1931, Painter 1913, Plett 1962a, 1962b, Precht and Freytag 1958, Richman 1973, 1977, Snetsinger 1955, Systshevskaja 1928, 1935, Taylor and Peck 1975, Thomas 1929, Wild 1969a, 1969b, Yates 1968), descriptions are now available for the courtship and mating behavior of approximately 50 of the 400 salticid genera. Crane (1949b) concluded that salticid courtship is a visual communication system. Visual sign stimuli are necessary and sufficient to release male courtship, although airborne pheromones may lower the male's threshold somewhat. During the courtship which ensues, the female responds to visual signals from the male's display. Apparently this represents the present consensus of opinion, and this is the representation of salticid courtship given in recent general works, such as Carthy (1965), Kaestner (1968) and Platnick (1971).

The behavioral elements associated with type 1 courtship are similar to motor patterns described for numerous other salticid species. However, the behavioral elements associated with type 2 courtship tend to show greater similarity to motor patterns that have been described in the courtship of spiders in other families with less highly developed vision. Another goal of this paper is to discuss these similarities.

The species used in this study was identified as *P. johnsoni* from descriptions of Peckham and Peckham (1909) and from museum specimens, including ones labeled by the Peckhams. Spiders that Peckham and Peckham (1909) described as *P. formosus* seem to be the same species as *P. johnsoni* (Jackson, unpublished data), as has been noted by Kaston (1972). *P. johnsoni* is a common species in western North America, where it occurs in relatively xeric habitats, such as oak woodlands and coastal dunes; but they do not occur in desert habitats. Although found in areas of fairly dense vegetation, I am unaware of populations from areas with extensive closed forest canopy.

Adult males tend to be 9 to 10 mm in body length; females, 10 to 14 mm. The cephalothorax, legs, palps, and ventral abdomen of both sexes are black. The males have red abdomens, sometimes with a faintly noticeable black longitudinal band. Females have red, orange, or gold dorsal abdomens, usually with a conspicuous black longitudinal band. There may be various small white or yellow markings associated with the lateral abdomen and the central band of the female. Chelicerae of both males and females tend to be iridescent green, and the face of the spider tends to be covered, to varying degrees, with white scales and setae. Although larger immatures of both sexes tend to resemble adult females, they are readily distinguished from the adults by the absence of reproductive organs.

Although the concept of animal communication has at times been given a very general meaning, encompassing virtually all stimulus-response relations, the more circumscribed

definitions of Wilson (1975) and Otte (1974) will be adopted here. Communication is "action on the part of one organism (or cell) that alters the probability pattern of behavior in another organism (or cell) in a fashion adaptive to either or both participants" (Wilson 1975). Signals are "behavioral, physiological, or morphological characteristics fashioned by natural selection because they convey information to other organisms" (Otte 1974). Motor patterns that probably function as behavioral signals during intraspecific communication in *P. johnsoni* are listed in Table 1. Each of these occurs primarily during intraspecific interactions. With these motor patterns, one individual probably creates a substantial sensory input for the other individual. (Abdomen twitching is a possible exception that will be discussed later.)

Before proceeding with a discussion of individual elements of behavior (Table 1), it will be useful to first provide a general characterization of the different types of interactions. Following Brown (1975), the term "display" will be restricted to visual signals. Type 1 courtship is characterized by display behavior; type 2 is not. Displays during type 1 courtship involve erected legs and include posturing, gesturing, and two types of dancing. Type 2 courtship consists of probing, tugging, and vibrating. Postmount courtship consists of tapping and scraping, with legs and palps, and stroking.

The behavior that occurs during interactions between adult males outside nests will be referred to as threat displays. Threat displays, which have been described for other salticid species (Crane 1949b), are signals employed during aggressive or agonistic behavior. Aggression is difficult to define, partly because this term is applied to a wide array of behaviors that are not necessarily closely related in function (see Huntingford 1976). A partially adequate definition is behavior of one individual that reduces the freedom or fitness of another (Wilson 1975). The specific functions of male aggressive behavior in salticids will be dealt with in a future paper. It will suffice to note here that this behavior leads to increasing the distance between two males.

Since much of the behavior of females and subadults during intraspecific interactions would seem to increase or maintain interspider distance, this will be referred to as aggressive or spacing signals also. Intermale aggressive behavior consists of hunched legs displays, embracing, and prodding. The aggressive behavior of females consists of erected legs displays, striking, embracing, lunging, charging, swaying, and truncated leaps, when outside nests. A female inside her nest employs aggressive behavior consisting of striking, embracing, pulling, bumping, and stabbing. Subadults share much of the female's repertoire of aggressive behavior. Males inside nests share at least two of the female's aggressive motor patterns, embracing and pulling.

The performance of erected legs displays by males when the female occupies the door of her nest is most likely an artifact of the laboratory. This will be discussed later. The performance of erected legs displays by males interacting with subadults outside nests, and the performance of probing, tugging, and vibrating by males interacting with either adult males or subadults inside nests may have been cases of mistaken identity, since in each case these motor patterns occurred only briefly.

METHODS AND TERMINOLOGY

Each time that quantitative data are presented, the number of interactions involved will be stated, since the sample sizes vary. This is because records for all interactions were not kept with equal completeness; and in each case, the subset of the recorded

interactions was selected for which the type of data of interest was recorded. The largest sample sizes are for male-female and male-subadult female interactions, since data for these were collected in conjunction with other studies (Jackson 1976). Except where noted, data are based on interactions during which the spiders occupied approximately 10 cm long clear plastic cages, and details concerning maintenance (Jackson 1974) and observation (Jackson 1976) procedures have been provided elsewhere. It will suffice to note here that spiders were maintained individually in the same type of cage used for observation. These cages contained holes plugged with corks, and most observations were initiated by introducing a spider through one of these holes into a cage in which another spider was being maintained. Each time, the spider introduced was a male, if a male was involved. If one spider occupied a nest, the other spider was the one introduced. The maintenance procedure provided continual food (*Musca domestica* L.) and water. Data in text are given as means \pm S. D.

ELEMENTS OF BEHAVIOR

The elements of behavior will be described and discussed here. (More exhaustive descriptions are provided by Jackson 1976.) Each element of behavior is provided with an index number in the following alphabetical list:

Apply palp, 46; Bend abdomen, 3; Bump (and heave), 37; Charge, 24; Chew, 30; Decamp, 13; Depart nest, 34; Dislodge male, 48; Elevate body, 2; Embrace (grapple and push), 27; Enter nest (and open door), 33; Erect legs, 5; Erected legs display, 10; Evict male, 40; Extend fangs, 14; Gesture, 7; Grapple (embrace and push), 27; Grip, 29; Heave (and bump), 37; Hold (and pull nest), 39; Hunch legs, 15; Hunched legs displays, 18; Linear dance, 8; Lower body, 26; Lunge, 22; Mount, 11; Open door (and enter nest), 33; Pose, 16; Posture, 6; Probe, 28; Prod, 19; Pull (and hold nest), 39; Push (embrace and grapple), 27; Rotate abdomen, 47; Scrape with legs, 43; Scrape with palps, 45; Spin, 33; Spin mount, 36; Spread palps, 1; Stab, 38; Strike, 21; Stroke, 44; Sway, 25; Tap with legs, 41; Tap with palps, 42; Truncated leap, 23; Tug, 31; Twitch abdomen, 4; Vibrate, 32; Wag, 17; Watch & follow, 12; Wave legs (and palps), 20; Wave palps (and legs), 20; Zigzag dance, 9. The frequencies with which these occurred in different types of interactions are summarized in Table 1.

I. Behavior Usually Associated with Both Spiders Outside Nests.

A.—Behavior Performed Predominantly by Males Interacting with Females.

1. *Spread palps*—The palps are spread by lateral, dorsal, and posterior movements that completely uncover the chelicerae (compare Fig. 1a and 1b.). Typically the palps are held in this position, at the sides of the chelicerae, as the male performs erected and hunched legs displays. Also the male's palps may be spread as he watches a female or a male. Males, females, and subadults spread their palps during embracing. However, females and subadults do not spread their palps when performing erected legs displays. As noted by Crane (1949b), spread palps occur during display behavior in a number of salticid species.

2. *Elevate body*—The cephalothorax is lifted away from the substrate by extension of the legs during body elevation.

3. *Bend abdomen*—The abdomen is flexed from the sagittal plane of the cephalothorax during bending, making an angle of up to 45° (Fig. 2b).

Table 1.—Frequency of occurrence of behavioral elements during interactions involving pairs of *Phidippus johnsoni*. Under type of interaction, first letter denotes sex (M: male, F: female); second denotes age class (A: adult, S: subadult); third denotes whether spider was inside (I) or outside(O) nest. Sex/age class of spider for which data are given is listed first. Numbers in parentheses following each element of behavior indicates percentages of interactions during which it occurred.

TYPE OF INTERACTION	NUMBER OF INTERACTIONS	BEHAVIOR
Adult Males		
M-A-O x F-A-O	1384	Twitch Abdomen (100), Erect Legs (100), Posture without Dancing (78.25), Gesture without Dancing (84.18), Linear Dance (11.71), Zigzag Dance (8.02), Embrace (18.21), Hunch Legs (0.65), Pose (0.65), Wag (0.29)
M-A-O x F-A-I	365	Twitch Abdomen (100), Probe (95.89), Tug (36.71), Vibrate (37.53), Embrace (19.18), Erect Legs (Female at Door) (38.73)
M-A-O x F-A-O Postmount	252	Twitch Abdomen (100), Tap with Legs (99.60), Scrape with Legs (96.03), Stroke (87.30), Scrape with Palps (86.51), Copulate (86.61)
M-A-O x F-S-O	40	Twitch Abdomen (25), Erect Legs (60), Posture without Dancing (60), Gesture without Dancing (60), Zigzag Dance (5)
M-A-O x F-S-I	1063	Twitch Abdomen (63.12), Probe (93.89), Tug (11.85), Vibrate (10.91), Erect Legs (Subadult at Door) (28.03)
M-A-O x M-S-O	19	Twitch Abdomen (31.58), Erect Legs (73.68), Posture without Dancing (57.89), Gesture without Dancing (26.32), Linear Dance (5.26), Zigzag Dance (5.26)
M-A-O x M-S-I	39	Twitch Abdomen (53.85), Probe (61.54), Tug (25.64), Vibrate (17.95), Erect Legs (Subadult at Door) (30.77)
M-A-O x M-A-O	60	Twitch Abdomen (100), Hunch Legs (100), Pose (100), Wag (100), Embrace (71.67), Prod (10), Erect Legs (13.33), Posture (13.33), Gesture (5)
M-A-O x M-A-I	30	Twitch Abdomen (100), Probe (16.67), Tug (36.67), Vibrate (3.33), Embrace (16.67), Hunch Legs (Other Male at Door) (56.67)
M-A-I x M-A-O	30	Twitch Abdomen (100), Embrace (16.67), Pull (16.67), Hunch Legs, At Door (60)

Table 1.—Continued

TYPE OF INTERACTION	NUMBER OF INTERACTIONS	BEHAVIOR
Adult Females		
F-A-O x M-A-O	1384	Twitch Abdomen (0.72), Strike (27.82), Lunge (3.18), Truncated Leap (4.12), Charge (5.64), Sway (1.81), Embrace (18.21), Erect Legs (28.90), Posture (28.90), Gesture (0.43), Hunch Legs (0.22), Pose (0.22), Wag (0.22)
F-A-I x M-A-I	365	Twitch Abdomen (0.55), Strike (57.53), Embrace (19.18), Pull (91.51), Bump (38.63), Stab (14.79), Erect Legs (At Door) (9.86)
F-A-O x M-A-O Postmount	252	Rotate Abdomen (86.51), Copulate (86.51)
F-A-O x F-A-O	13	Erect Legs (61.54), Posture (61.54), Gesture (30.77)
F-A-O x F-A-I	32	Twitch Abdomen (6.25), Tug (9.37) Erect Legs (Other Female at Door) (15.63)
F-A-I x F-A-O	32	Strike (9.37), Embrace (9.37), Pull (28.13), Erect Legs (At Door) (18.75)
F-A-I x M-S-O	15	Strike (20), Pull (6.67), Bump (6.67), Erect Legs (At Door) (6.67)
F-A-I x F-S-O	20	Strike (25), Pull (20), Bump (10), Erect Legs (At Door) (45)
Subadults		
F-S-O x M-A-O	40	Erect Legs (37.50), Posture (37.50), Gesture (10), Strike (20), Truncated Leap (5), Charge (2.50), Embrace (12.50)
M-S-O x M-A-O	19	Erect Legs (63.16), Strike (10.53), Embrace (5.26)
F-S-I x M-A-O	1063	Strike (32.55), Embrace (5.55), Pull (62.84), Bump (7.26), Stab (6.30), Erect Legs (At Door) (4.42)
M-S-I x M-A-O	39	Twitch Abdomen (2.56), Strike (5.13), Embrace (12.82), Pull (46.15), Erect Legs (At Door) (20.51)
M-S-O x F-A-I	15	Tug (6.67), Erect Legs (Female at Door) (6.67)
F-S-O x F-S-I	15	Tug (13.33), Erect Legs (Other Subadult At Door) (13.33)
F-S-I x F-S-O	15	Strike (20), Pull (13.33), Erect Legs (At Door) (13.33)

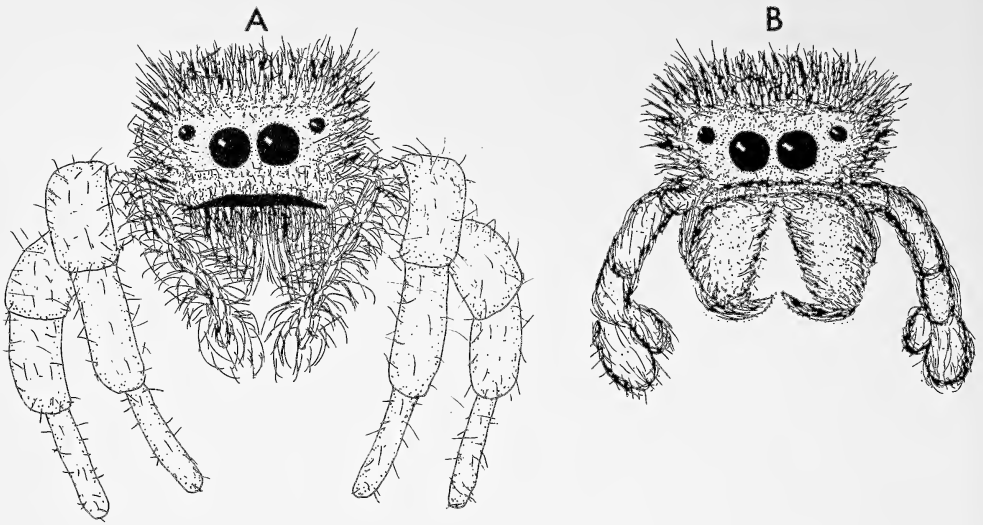


Fig. 1.—Face of *P. johnsoni*: 1a, female, palps in rest posture, fangs closed; 1b, male, palps spread, fangs extended (legs not shown).

4. *Twitch abdomen*—During abdomen twitching, the abdomen moves up and down in the sigittal plane, over a distance of 1 mm or less. Adult males invariably perform this motor pattern during courtship interactions with adult females and during aggressive interactions with other males, and they frequently twitch their abdomens during interactions with subadults. Females and subadults rarely twitch their abdomens. In addition, this behavior never occurred in contexts other than interactions with other spiders.

The male's abdomen tends to twitch as he performs erected and hunched legs displays. This behavior is also associated with embracing, probing, tugging, vibrating, prodding, tapping and scraping with legs and palps, and stroking. In addition, abdomen twitching may occur as the male watches another spider, walks on a nest, or stands otherwise inactive on a nest. Females and subadults twitch their abdomens considerably less often than males (Table 1).

Twitching, pulsating, or vibratory movements of the abdomen during courtship have been reported for a great many species of spiders (see Gerhardt and Kaestner 1937). Although there are stridulatory organs associated with the anterior abdomen and posterior cephalothorax of some species that come into play during courtship (Gwinner-Hanke 1970), this is not the case in *P. johnsoni* and many other species. Also, no audible sounds are produced by *P. johnsoni* during abdomen twitching. Ultrasonics might be considered. Another possibility is that these movements transmit vibratory stimuli through the substrate during type 1 courtship, through the nest during type 2 courtship, and directly to the female's body during postmount courtship. However, the male's abdomen does not normally contact the substrate, nest, or female's body during twitching, so the vibrations involved would have to first pass through the male's legs. During type 1 courtship, twitching of the male's bright red abdomen might be a visual signal. However, since the male usually faces the female during type 1 courtship, these low amplitude abdomen movements are likely to be visually obscured by the male's legs and cephalothorax.

Non-communicatory functions should be considered also. Spiders lack extension muscles for most of the joints of their legs, and leg extension is brought about largely by hydrostatic pressure (Wilson 1970, Anderson and Prestwich 1975) generated by the cephalothoracic musculature. Perhaps abdomen twitching is involved in countering the tendency toward pooling of hemolymph in the abdomen. In general, leg movements of the male during courtship and threat have a “jerky” and “vigorous” appearance, and perhaps these movements require the maintenance of relatively great hydrostatic pressure in the cephalothorax. Also, the various movements of structures on the male’s palpal organ and the transfer of semen are probably mediated by a hydrostatic mechanism (see Cooke 1969), and abdomen twitching during and preceding copulation may be associated

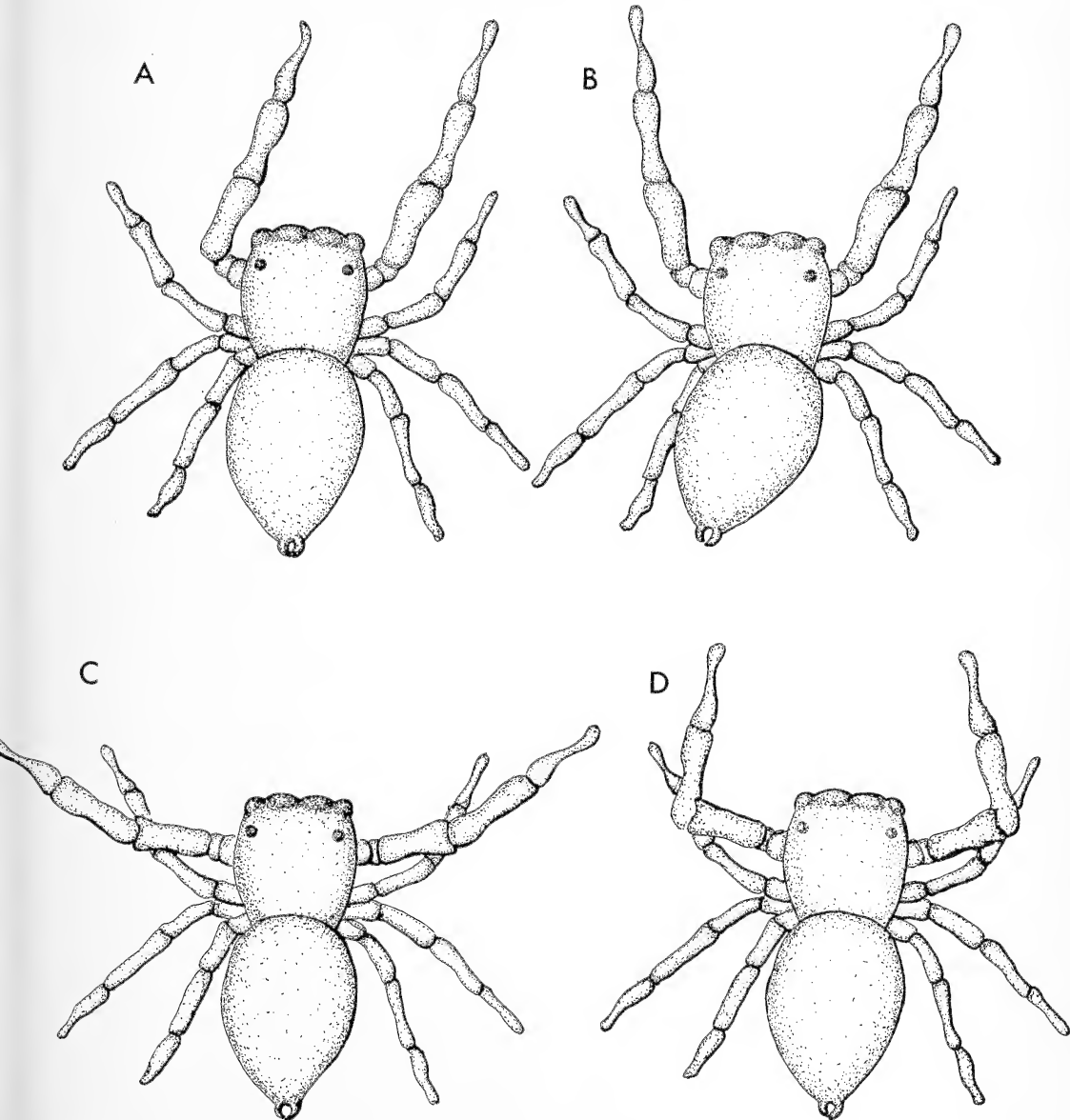


Fig. 2.—Positions of legs I during displays: 2a, erected position A; 2b, erected position B, abdomen bent toward left as spider steps toward right; 2c, hunched legs; 2d, legs extended during wagging.

with maintenance of relatively great hydrostatic pressure, related to the copulatory mechanism.

5. *Erect legs*—Only legs I are erected, and erected legs have a stiff appearance. The patella generally makes an angle of about 135° to the femur. From the patella to the tarsus, each leg is approximately straight. Generally both legs I are erected simultaneously. With respect to the sagittal plane, there are two modal positions. Positions intermediate between these are seen comparatively rarely. In Position A, the two legs are nearly parallel to the sagittal plane and to each other (Fig. 2a). The tarsi may point somewhat inward. In Position B, the legs are held at approximately 45° to the sagittal plane (Fig. 2b).

6. *Posture*—When a male postures, his legs I are held motionless while erected in either Position A or B (Fig. 2). Position B is the usual one adopted by posturing females, but both positions are common for males.

7. *Gesture*—During gesturing the spider's erected legs move repeatedly from position A to position B (Fig. 2), and vice versa. These movements have a sudden, jerky appearance compared to the smoother appearance of leg waving. Normally the legs are simultaneously elevated as they go from position B to position A. A single gesture takes less than 1 sec for completion. Males frequently gesture, females only rarely gesture (Table 1). As a spider postures or gestures, it may walk or remain in one location. When walking occurs, sometimes it occurs in one of two relatively stereotyped patterns that are referred to as dancing. Only males dance. Walking with legs erected, without dancing may also occur.

8. *Linear dance*—A linear dance consists of walking alternately forward and backward, while posturing or gesturing. Typically the distance traveled is 1 or 2 cm in each direction. Since the number of forward steps need not correspond to the number of backward steps, the net effect may be that the male gets closer to or farther away from the female; or the two spiders may remain the same average distance apart.

9. *Zigzag dance*—A zigzag dance consists of walking sideways, one direction then the other, while posturing or more often gesturing. Facing the female, the male moves in an arc for a variable number of steps in each direction, covering a distance of one or several centimeters. Usually the male's abdomen is bent such that the posterior end points away from the direction in which he moves (Fig. 2b). Also his cephalothorax is usually raised on the side opposite the direction of movement. The dance may gradually cause the male to circle, approach, or withdraw from the female, or he may remain in essentially the same location.

10. *Erected legs displays*—Four categories of erected legs displays are referred to in Table 1: linear dancing, zigzag dancing, posturing without dancing, and gesturing without dancing. During erected legs displays, the male faces the other spider; frequently his body is elevated by extension of his other legs; and usually his abdomen twitches and his palps are spread. Erected legs do not occur outside the context of intraspecific interactions. Each type of dancing occurred in only approximately one-tenth of the observed interactions.

Species-specific patterns of extension and movement of the male's legs, especially his legs I, would seem to be a very common characteristic of display behavior among salticid species (Crane 1949b). Specializations similar to erected and hunched legs, gesturing, and wagging probably occur in many other salticid species also, but in general, descriptions are lacking in sufficient detail to determine the degree of resemblance. Also, as noted by Crane (1949b), some students of salticid behavior seemingly failed to distinguish between

behavior involving simply raising or waving legs and the specialized leg postures and movements involved in display behavior. These are probably distinct in most salticids, although the leg movements involved in display may be evolutionary modifications of leg raising and waving (Crane 1949b).

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11. *Mount*—A mounted male is one that is standing on some part of the female's body for more than one second. Mounting is any behavior that brings this about. Data were collected concerning 303 cases of males mounting females outside the nest. In two cases, the male mounted by leaping onto the facing female. In all other cases, the male mounted by walking onto the female. In most cases (276), the female was facing the male when he mounted. On 11 occasions, the female faced approximately 90° from the male, and she faced approximately 180° away in 14 cases. (Orientation was recorded in the nearest 90° .) Copulation did not always follow mounting. Considering 302 interactions during which the male mounted the female at least once, copulation did not occur in 17.22%. This includes interactions in which females occupied and ones in which they did not occupy nests, and the data for each are comparable.

12. *Watch and Follow*—While remaining in one location, with legs not erected, a spider watches an object by maintaining an orientation such that its anteromedial eyes continue to face the object. This may involve elevating the body or pivoting. With legs not erected, a spider follows an object by running or walking forward while maintaining an orientation such that the anteromedial eyes continue to face the object. Episodes during which the male watches or follows the female frequently occurred during type 1 courtship interactions. While a male courts a female outside her nest, the most common activity of the female is to watch the male. Females rarely follow decamping males, however.

13. *Decamp*—Decamping is any locomotion (walk, run, leap) that carries one spider away from another.

B.—Behavior Performed Predominantly by Males Interacting with Other Males.

14. *Extend Fangs*—At rest, the fangs are flexed against the basal segments of the chelicerae (Fig. 1a). They may be extended ventrally from this position to varying degrees during interactions with other spiders (Fig. 1b).

15. *Hunch Legs*—Only legs I are hunched. When a spider hunches its legs (Fig. 2c) the femora are raised, usually making an angle of approximately 45° with the substrate. As in the case of erected legs, hunched legs are held nearly straight from the patellae to the tarsi; and the hunched legs have a stiff appearance. Unlike an erected leg or one that is simply raised, the femur-patella joint of a hunched leg is strongly flexed (generally approximately 90°) with the tarsi angled toward the substrate at approximately 45° . The tarsi may touch the substrate, or they may be held a few millimeters above it. Hunched legs have the effect of increasing the apparent size of the displaying spider, as is common for threat displays of salticids (Crane 1949b) and other animals (Eibl-Eibesfeldt 1970).

16. *Pose*—When posing the spider stands with his legs I hunched and remains nearly or completely motionless except for abdomen twitching.

17. *Wag* During wagging the spider's legs are alternately elevated and lowered mostly by extending and flexing the femur-patella joints (Fig. 2d). The two legs are generally

wagged simultaneously, not always strictly in phase. A single wag usually requires approximately one second for completion.

18. *Hunched Legs Displays*—Posing and wagging are referred to jointly as hunched legs displays. Hunched legs are usually associated with elevated bodies, spread palps, and twitching abdomens. Both legs I are always hunched at the same time. Hunched legs displays do not occur outside the context of intraspecific interactions. Something similar to a zigzag dance may develop during hunched legs displays. One male walks sideways, first in one direction then the other, while wagging or posing. The other male may stand wagging or posing in one location, pivoting so as to continually face the first male. On other occasions, both individuals may walk sideways simultaneously, revolving alternately clockwise then counterclockwise at opposite ends of an imaginary circle.

Unlike males with erected legs, males with hunched legs may have partially extended fangs. The spider's fangs are employed in predatory behavior, and they were employed in every instance witnessed in which one spider injured or killed another in the laboratory. Behavior in which the fangs are made conspicuous to another individual is consistent with a function related to threat, and fang extension occurs in a number of other salticid species during interactions between males (Crane 1949b). Males only rarely hunch legs in the presence of females, and females very rarely hunch legs. On the other hand, this behavior almost invariably occurs when two males interact.

19. *Prod*—A male may prod while following a decamping male. The prodding male's face touches the decamping male's posterior abdomen intermittently, sometimes causing the prodded male to slide several millimeters across the substrate.

C.—Behavior Performed Predominantly by Females.

20. *Wave Palps and Wave Legs*—At rest the palps are folded over the front of the iridescent green chelicerae (Fig. 1a). When the palps are waved, they move up and down, repeatedly exposing the chelicerae. The two palps move in parallel over a distance of several millimeters. The spider waves its legs I by alternately raising them to a point approximately 45° to the sagittal plane, generally both moving in parallel. As there is generally considerable flexion at several joints, raised legs lack the stiff appearance of erected legs.

Leg waving and especially palp waving are very common activities for spiders of all ages and both sexes, and they occur in varied contexts. For example, a spider normally waves its palps and legs during momentary pauses as it walks through its environment, and spiders normally wave their palps actively as they watch and stalk prey. During interactions between conspecifics, females and immatures frequently wave their palps and sometimes wave their legs, but males rarely do either. Leg and palp waving occur especially while the female or subadult watches the other spider during interactions.

Crane (1949b) noted that in a number of salticid species, females frequently wave their palps as they watch displaying males. Possibly leg and especially palp waving are stimuli involved in species or sex recognition since palp waving patterns differ among salticid species. For example, I have noticed that during waving, the palps of *Phidippus regius* C. L. Koch and *P. johnsoni* move parallel with each other, while those of *Plexippus paykulli* Andouin move 180° out of phase with each other. Of course, sensory (suggested by Crane 1949b) and other functions should be considered as well.

21. *Strike*—During a strike, the female's legs I are moved simultaneously, and in phase forward and downward from erected position B, such that the tarsi of these legs are brought into contact with the substrate or the male (Fig. 3 and 4). These movements occur in a fraction of a second and have a sudden "snap-like" appearance.

22. *Lunge*—During a lunge, the female's body is rapidly and suddenly jerked forward a few millimeters, then it returns to its original position. Evidently the spider's legs do not leave the substrate. The duration of a lunge is only a fraction of a second. Usually the female is quite close to the male.

23. *Truncated Leap*—A truncated leap resembles a lunge except that the female's legs leave the substrate. The leap carries the spider forward only a few millimeters; and generally only one occurs at a time, followed by the female decamping. Truncated leaps tend to occur when the male is relatively close, but farther away than when the lunges occur.

24. *Charge*—A charging female runs toward the male over a short distance (usually 1 or 2 cm), then she abruptly stops and usually decamps.

25. *Sway*—A female sways by extending the legs on one side of the body while flexing those on the other side, causing the body to move to the left or the right. There is no stepping, and the legs remain on the substrate except that her legs I may be erected during swaying. Typically the spider sways to one side, followed by swaying through the original position over to the other side, and then moving back to the original position. The process requires 2 or 3 sec. The female's body may be elevated, and often her abdomen is bent away from the direction in which she sways.

26. *Lower Body*—When the body is lowered, it is positioned closer to the substrate than is the case during walking and standing. Normally, lowering the body is followed by the male walking onto the female. Lowering of the body is a preliminary to mounting in some other salticid species also (Crane 1949b). During type 1 courtship outside nests, when the female lowered her body, the male always mounted. In these cases, the female faced the male, and the male mounted by walking onto the female. However, lowering of the body did not precede 90 of the 276 cases in which males walked onto facing females.

27. *Embrace, Grapple, and Push*—During an embrace the two spiders are face to face with their chelicerae and/or legs I touching. An embrace may begin in a number of ways, but it is usually initiated by the female. A female may erect her legs and initiate an embrace as the male begins to walk onto the female, for example. Sometimes a strike

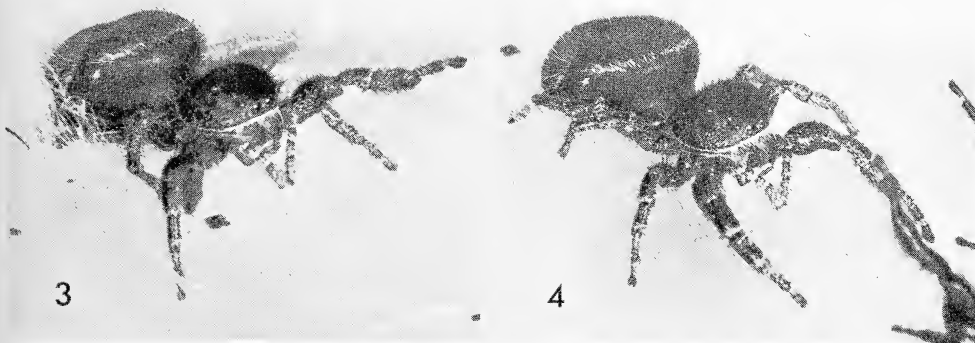


Fig. 3.—Female moves legs I upward and medially into erected position B, as she departs nest (on left) and begins a strike. Right leg I out of focus. Palps wave. Abdomen bent to right.

Fig. 4.—At completion of strike, female's leg I on substrate but no longer stiff (see Fig. 3). Note erected legs of male on right.

precedes the embrace. Other times, a female may walk toward the male, with or without erected legs, and initiate the embrace. The male and/or female sometimes have erected legs (position B) during the embrace. The male and female may be almost motionless during the embrace, or they may grapple and push. During grappling, the embracing spiders remain in one location as they repeatedly shift the configuration of their legs I and cephalothorax. While pushing, one or both embracing spiders walks. As a result, one of the spiders may be pushed backwards. Frequently the two spiders alternately push each other over short distances. Sometimes males manage to go directly from an embrace to a mounted position.

General Comments on Female Behavior—Crane (1949b) noted that in the salticids the majority of display behavior is performed by males, although females of some species display occasionally similarly to males, and sometimes females have “quirks” of their own. However, displays of female salticids have generally received little attention. Part of the display repertoire of *P. johnsoni* seems to be restricted to adult females and subadults, since males were never witnessed to strike, lunge, charge, sway, or perform truncated leaps. Subadults performed most and adult females performed all of these. The fact that all were not seen performed by subadults may have been simply the result of the relatively few observations made with subadults outside the nests.

Females have been observed to strike when approached by relatively large arthropods such as gnaphosid spiders and centipedes, suggesting an antipredator function for this behavior in certain circumstances. *Phidippus regius* (Edwards 1975, Jackson 1973) and a less closely related salticid, *Lyssomanes* (Eberhard 1974) have been reported performing apparently similar behavior.

II. Behavior Usually Associated with a Female Inside a Nest and a Male Outside a Nest.

A.—Behavior Performed Predominantly by Males.

28. *Probe*—Probing occurs with the male's tarsi I on the nest (Fig. 5). The spider's other legs may or may not touch the nest. The legs I are moved alternately anteriorly and

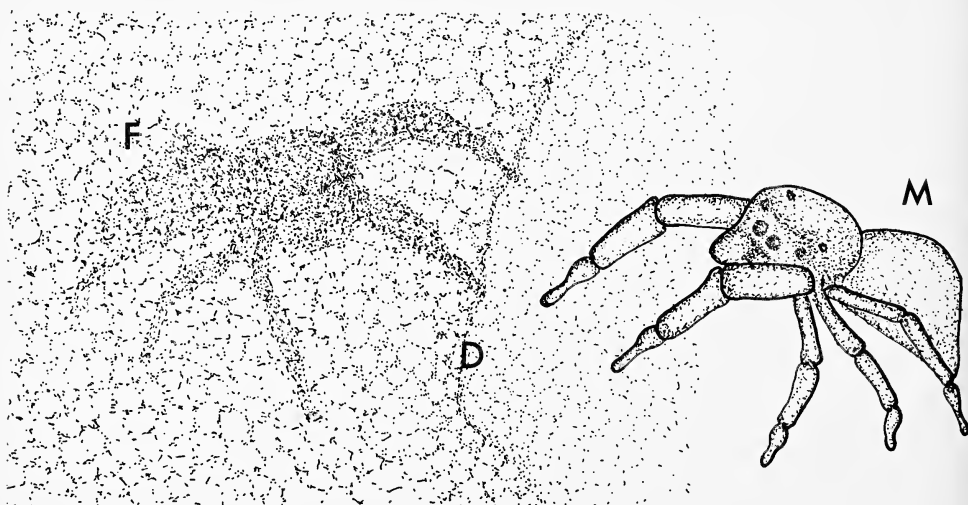


Fig. 5.—Male (M) probing nest near door (D). Female (F) inside nest, holding door.

posteriorly over a distance of several millimeters, creating the impression of suddenly and jerkily pushing and pulling on the silk. The two legs move in parallel. A single probe requires less than one second. A common pattern is for the male to make a series of three or so probes, pausing for approximately one second, probing again, and so forth. Although the spider does not walk during probing, its body may move anteriorly at the beginning of a probe.

Probing occurred in the majority of interactions in which males encountered females or subadults inside nests and in a few cases when males encountered other males inside nests. Females and subadults did not probe, and spiders did not probe when entering their own nests. The most common location of probing was within a few millimeters of the door (Fig. 5). This occurred in 91.21% of the interactions during which probing occurred, but probing at other locations occurred in only 34.64%. (Data for interactions involving females, males, and subadults inside nests were comparable.)

29. *Grip*—A spider grips by closing its fangs around the silk (Fig. 6). Sometimes one or both legs I or the palps guide the silk between the extended fangs.

30. *Chew*—During chewing, the fangs and basal segments of the chelicerae open and close against the gripped silk. Chewing was always followed or preceded by tugging. Since this behavior was relatively inconspicuous to the human observer, the frequency of its occurrence was not recorded.

31. *Tug*—While gripping the silk, the spider tugs by moving its cephalothorax alternately dorsally and ventrally over a distance of a few millimeters (Fig. 6). Each tug generally requires one second or less. Although males tug more often, females and subadults also tug when they encounter conspecific spiders inside nests. Considering all interactions between spiders during which gripping occurred, episodes of tugging occurred during 98.61% of these, vibrating while gripping occurred during 35.54%, and at least one of these occurred in every instance.

Considering only interactions during which tugging occurred, a hole was formed in the nest after a prolonged period of tugging and chewing at one location in 4.48% of the

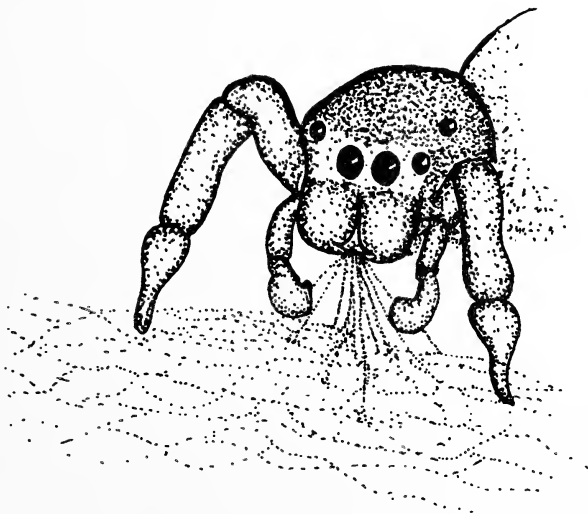


Fig. 6.—Male grips silk with fangs and tugs.

male-female interactions and during one male-male interaction. This suggests a mechanical function for this behavior, related to tearing and possibly digesting the silk. It should be noted, however, that in most cases the spider frequently changed its location on the nest during tugging, and tugged for only a few seconds or minutes at a given location. When holes were formed in nests, tugging and chewing were concentrated at one location for 62.4 ± 41.05 min (range 25 to 137 min, $n = 7$). Perhaps tugging has both a signal and a mechanical function, with the relative importance of the two depending on the degree to which tugging is prolonged and concentrated. Perhaps the mechanical function was the evolutionary antecedent of the signal function. Occasionally spiders tug while spinning inside nests with no other individuals present. Unfortunately data are not available on the frequency and context of tugging during spinning episodes. Perhaps spiders monitor the density or firmness of the nest by tugging inside their nest, and this may be an additional function of this behavior.

32. *Vibrate*—Vibration is a series of extremely rapid, low amplitude dorsal-ventral movements. The spider's tarsi I are always on the nest, although the other legs may or may not touch the silk (Fig. 7). Vibration is distinctly different from probing and tugging, in both amplitude and time course. The movements involved seem to occur over a distance of less than one millimeter, with a duration of only a fraction of one second. Usually five or so dorsal-ventral movements are made in one bout which lasts less than one second. Vibration has the appearance of a sudden and faint blurring of the spider and of the silk in his vicinity. Movement of the spider is less conspicuous than movement of the silk.

Considering all interactions during which vibration occurred, although episodes of gripping while vibrating occurred in many (39.08%), episodes of vibrating without gripping were more common (86.97%); and sometimes both occurred in the same interaction.

Only males vibrate. Vibration does not occur when the male is at his own nest. It occurs when the male encounters a subadult or especially a female inside a nest, but only rarely when he encounters another male inside a nest.

Very rapid vibratory movements of the legs and/or body occur during the courtship of some Anyphaenidae, Clubionidae, and Ctenidae (Braun 1958, Bristowe 1958, and Melchers 1963). These are non-web spiders, and it has been suggested that the vibrations are transmitted to the female from the male through the substrate. Since audible sounds are produced in some cases, acoustical communication is another possibility in some species. The vibratory courtship of these species seems to bear a certain resemblance to vibration in the courtship of *P. johnsoni*. The substrate for *P. johnsoni* is always the female's nest. Although no audible sounds are produced by *P. johnsoni* males, the possibility of ultrasonic communication should be considered.

33. *Open Door and Enter Nest*—The nest door may be a slit whose two sides are one millimeter or less apart. To open the nest door, the spider moves its legs I anteriorly and dorsally. These movements superficially resemble probing, but occur at a slower velocity and greater amplitude and lack the sudden jerky appearance of probing. Also, the extended legs lack the stiff appearance associated with probing. Once the tarsi enter the door, the spider walks forward, lifting its legs I somewhat, and enters the nest. This motor pattern occurs when spiders enter their own nests, as well as when they enter nests occupied by other spiders. There are several circumstances under which a spider may enter a nest without opening the door. If the door is wide, the spider may simply walk into the nest. A male may enter through a narrow door on a female's nest while probing

or embracing. Occasionally males make holes in the nests of females and enter through these.

In 139 instances when males entered nests occupied by females, entrance was by a hole he formed in six cases, and through the door in 133. If the female pulls on the nest while the male probes at the door, or if the spiders embrace at the door, entering the nest may take many minutes, during which time the male gradually gets further and further into the nest. The spiders were embracing during 27.73% of the observed entrances.

Copulation did not always follow when a male entered a nest occupied by a female. Considering 30 interactions during which the male entered the female's nest at least once, copulation did not occur in 45.48%.

When spiders cohabit, after the subadult female molts the male enters her chamber. In most cases, the manner in which the male entered was not witnessed. Considering the 28 instances in which entrance into the newly matured female's chamber was observed, there were two instances in which the male entered by a hole he created in the layers of silk separating the two chambers. In the other cases, the male entered by one of the doors on the female's chamber.

34. *Depart Nest*—This term will be applied to instances in which a spider walks from inside the nest to outside, distinguishing it from cases in which the female evicts the male.

35. *Spin*—Two forms of spinning are readily discerned. The spider fastens attachment discs by positioning its spinnerets on the nest or substrate. The abdomen is held momentarily in this location as a thread is fastened. During sweep spinning, the spider walks slowly forward, bending its abdomen alternately to the left and to the right, trailing silk. Both types of spinning occur when a male constructs a second chamber on the nest of a subadult female. In addition, a male may perform both while inside the nest of an adult female, although a bout of spinning under these circumstances normally lasts no longer than a few minutes before the male switches to some other activity. Females and subadults also may spin briefly during interactions with males. Quantitative data concerning these types of spinning were not collected.

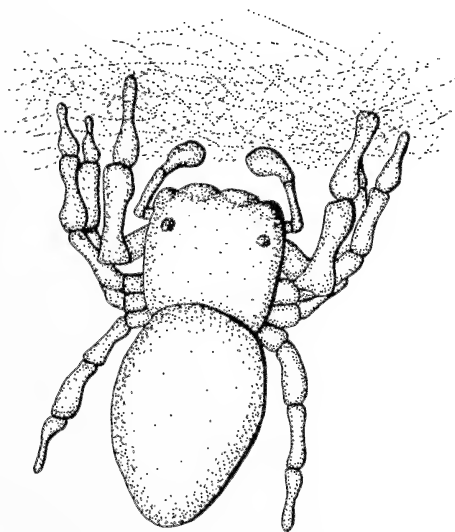


Fig. 7.—Male vibrates on nest.

36. *Spin Mount*—A male spin mounts by walking onto the female's dorsal surface, as he sweep spins. The female may be facing any direction relative to the male. For one or two seconds the male may continue to sweep spin after he mounts. Although this method of mounting was never observed while females were outside nests, it was common during prolonged interactions with females inside nests. For some time the male may spin at a distance from the female before approaching her sweep spinning. Data were collected for 82 interactions during which mounting occurred while females occupied nests. In 4.88% of these, spin mounting occurred. Each of these was a rather lengthy interaction, lasting for several hours. However, spin mounting occurred in 24.44% of 90 interactions in which males were observed mounting recently molted females with whom they had cohabited. This is a minimal estimate, since only a portion of the instances of mounting were witnessed in many of these interactions.

As in *P. johnsoni* spinning by males occurs during the courtship of some web spiders, including some Amaurobiidae, Araneidae, Linyphiidae, Oecobiidae, Theridiidae, Dictynidae, and Uloboridae (Bristowe 1929, 1958, Gerhardt 1928, Glatz 1967, Kaston 1970, Locket 1926, Robinson and Robinson 1973). These include seemingly aimless spinning in the web, construction of special threads on which mating subsequently takes place, and spinning while on the female. Spinning while on the female also occurs in the courtship of some non-web species, including some thomisids (Bristowe 1926, 1931, 1958, Gerhardt 1933, Kaston 1936) and a salticid, *Pellenes umatillus* Peckham and Peckham (Griswold 1977). When in the presence of females, males of the vagabond spider *Pardosa amentata* (Lycosidae) engages in a specialized spinning procedure which does not occur in the absence of females (Richter and van der Kraan 1970). To my knowledge, *P. johnsoni* is the only species for which spinning simultaneous with mounting has been reported. In each of these cases spinning probably has a communicatory function, although this has not been the conclusion of all authors.

General Comments on Behavior of Males—In type 2 courtship, tugging and, especially, probing and vibrating by males bear a strong resemblance to elements of courtship behavior in various web-building groups such as the Agelenidae, Araneidae, and Dictynidae. In these spiders the web is an adaptation related to prey capture, which is not true of the nests of salticids. The web either directly traps the prey or it simply puts the prey at a physical disadvantage relative to the spider. The web is also an extension of the spider's sensory system. The spider detects prey by vibrations transmitted through the web. Intraspecific communication occurs through this web-related sensory system also. During courtship, movements by one individual on the web set up vibrations that are transmitted by way of the silk to the other individual. These movements, involving the legs or the entire body have been referred to as "plucking," "tweaking," and so forth. Unfortunately detailed descriptions are rare (see Gerhardt and Kaestner 1937, Jackson 1976, and Platnick 1971 for reviews).

Very likely a similar coupling of the spider's vibratory sensory systems and silk occurs in the salticid *P. johnsoni* related to use of their nests during courtship. The salticid nest, like the webs of other spiders, has become a "substrate for communication" (Witt 1975). Like the web, the nest is a structure made of silk. It seems probable that structures made from silk share certain vibration transmission properties, and that similarities in vibratory courtship behavior can be related to these properties.

B.—Behavior Performed Predominantly by Females.

37. *Heave and Bump*—While inside the nest the spider heaves by extending its legs, causing the body to move dorsally (Fig. 8), pressing against the inner surface of the nest and causing the nest to bulge outward quite noticeably. The amplitude of this movement is rather great, approaching full extension of the legs at times. Velocity of the movement is relatively slow (duration of individual heaves, approximately 1 sec). Also the spider may maintain its body in the elevated posture for one second or longer after a heave. Spiders of both sexes and all ages may heave while spinning alone inside the nest. Perhaps one of the functions of the behavior is related to monitoring the tension or mass of the nest. However, an additional communicatory function for females and subadults seems likely since they frequently heave when there is another spider on their nests, with no associated spinning. Under these circumstances, heaving occurs interspersed with bumping, from which it differs in its slower velocity.

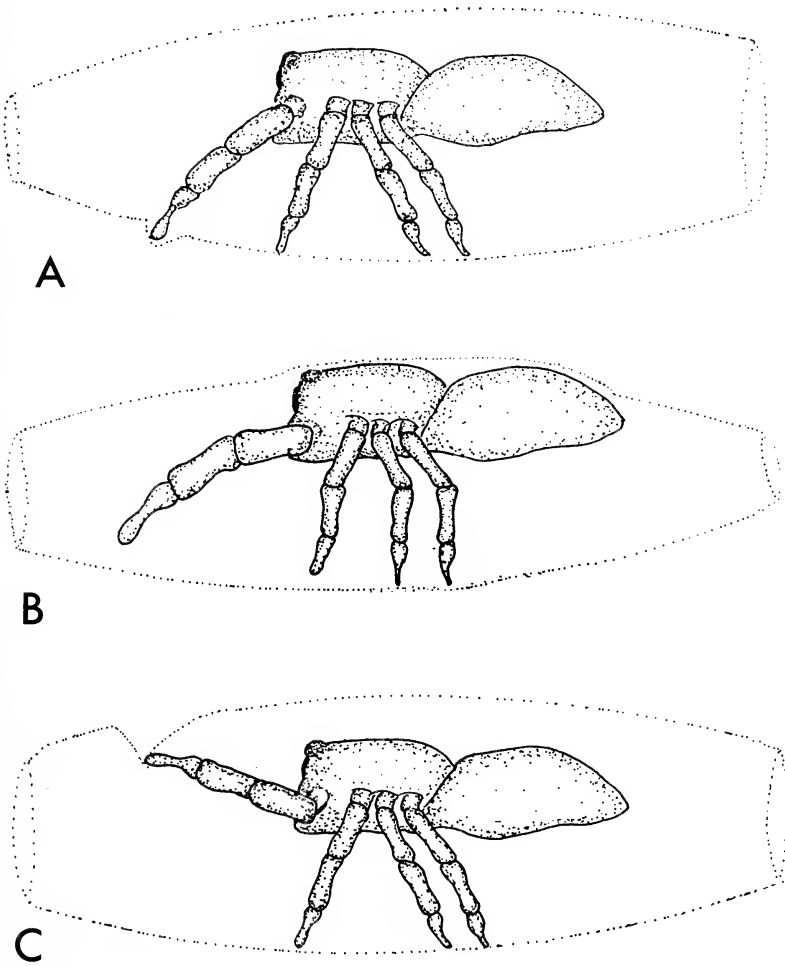


Fig. 8.—Behavior of spider inside nest (cross section of nest indicated by dotted line): 8a, stab, legs I moving downward; 8b, heave and bump, spider's body moving upward; 8c, pull on nest, legs I moving downward.

A female bumps by suddenly and rapidly extending, then flexing, her legs, causing her cephalothorax to hit the inner dorsal nest surface (Fig. 8). As a result the nest moves conspicuously. The male is often on the nest, dorsal to the bumping female. On a few occasions, the male fell off the nest when the female bumped. Most frequently the spider heaves and bumps from a location in the nest approximately ventral to the male.

38. *Stab*—While inside their nests, females and subadults stab by rapidly moving their legs I ventrally, with their tarsi oriented toward the inner ventral surface of the nest, causing "pin-point" bulges in the silk (Fig. 8). Stabs are typically made at locations approximately ventral to the male on the nest.

39. *Pull and Hold Nest*—The female pulls the nest by moving her legs I dorsally until her tarsi contact the inner dorsal nest surface (Fig. 8). Next her legs I move ventrally, pulling the silk, until the tarsi touch the inner ventral nest surface. By far the most common location for pulling is within a few millimeters of the nest door. Generally this occurs as the male probes and vibrates near the nest door. Also a female may pull on the nest at a location approximately ventral to the male's location on the nest or close to the location of a male in another chamber. When the male and female are inside the same chamber, the female may pull the nest just anterior to the facing male.

Considering all interactions during which pulling on the nest occurred, pulling within a few millimeters of the door occurred in 95.29%, while pulling at other locations occurred in only 21.23%. Interactions involving spiders of differing sex and maturity were comparable. However, only adult and subadult females were observed to pull at locations other than the vicinity of the door.

Pulling the nest is frequently, but not always, followed by holding the nest, during which the female's tarsi I hold the dorsal nest layer against the ventral. Generally the most common activity of a female inside a nest during an interaction with a male is to hold the nest in the vicinity of a probing male at the door.

Females, males, and subadults inside nests pull and hold when another spider is at their nests. When pulling and holding occurs at the door, a non-signal function is a possibility since these motor patterns might physically impair the intruding spider's ability to enter the nest. This does not preclude an additional communicatory function, especially in cases of pulling beneath a male on the female's or subadult's nest. It is noteworthy that all cases of pulling by males inside nests occurred at the door. Perhaps the signal function is restricted to females and subadults.

40. *Evict Male*—The female evicts the male by pushing him so that he is moved, posterior end first, to the outside of the nest.

III. Postmount Behavior.

41. *Tap With Legs*—Most commonly, tapping with legs occurs with the male's anterior ventral cephalothorax positioned over the female's posterior dorsal abdomen, with the male and female facing in opposite directions (Fig. 9). In this position the male simultaneously taps the right and left side of the female's abdomen by moving his legs I medially and ventrally such that his tarsi contact the female's abdomen.

42. *Tap with Palps*—Tapping with palps consists of alternate dorsal and ventral movements of the palp femora, causing the tarsi to alternately tap the female's body (Fig. 9). Each movement is generally over a distance of one millimeter or less and last approximately one second. This rather inconspicuous behavior occurs while the male taps with his legs, and is not listed separately in Table 1.



Fig. 9.—Mounted male (upper) taps female's abdomen with legs and palps. Female stands on nest with her body lowered. Male's body covers female's cephalothorax.

43. *Scrape With Legs*—The typical location of scraping is close to the one adopted during palp application, except that the female's abdomen is not rotated. In this position the male and female face in opposite directions with the male's anterior ventral cephalothorax over the female's posterior dorsal abdomen. The male leans to one side, and his leg I on that side passes over the female's leg IV. Positioned somewhat obliquely across the female, with his cephalothorax angled slightly ventrally, the male scrapes on the female's lateral abdomen with the tarsus on the side toward which he leans. The tarsus moves alternately in one direction then the other, over a distance of a few millimeters, at a frequency of two or more per second.

44. *Stroke*—Previous to stroking, the male leans to one side and scrapes with the leg on that side. To stroke, the male leans farther to that side and carries the other leg I dorsally across the female's leg IV. With this leg I flexed and its tarsus touching the female's abdomen, alternate dorsal and ventral movements are made (Fig. 10). Stroking is a slower movement than scraping, and the tarsus moves over a greater distance. If the female's abdomen rotates while the male strokes, the male switches to palp scraping.

45. *Scrape With Palp*—During and after rotation of the female's abdomen, the male scrapes with his palp by moving the palp on the closer side alternately back and forth such that the palpal organ moves on the female's ventral abdomen, usually on or near the epigynum.

46. *Apply Palp*—A palp is applied when the palpal organ is positioned on the epigynum and scraping ceases. In this study copulation is considered to be the time during which the palps are applied. Gerhardt and Kaestner (1937) proposed a classification of copulatory postures that has gained general acceptance. The salticids adopt

posture No. 2, in which the male and female face opposite directions, and the male's ventral surface is against the female's dorsum. During transfer of semen in spiders the embolus enters the female's copulatory pore. Embolus insertion must occur during at least part of the time that the palp is applied, in *P. johnsoni*, but I was unable to observe this. Frequent expansions and contractions of the hematodocha are usually noticeable while the palp is applied.

47. *Rotate Abdomen*—As the male strokes, the female's abdomen rotates at the pedicel, with her cephalothorax remaining stationary (Fig. 10). As a result, the ventral surface of the abdomen moves dorsally with respect to the cephalothorax. During copulation the abdomen is rotated 45° to 90° . At the end of a palp application, the male moves away the leg I which he had used for stroking. When this happens the female's abdomen immediately sways back to its normal position. Sometimes stroking by the male was not followed by scraping with palp and copulation. In these cases the female's abdomen rotated only partially then slowly rolled back to its original position. If the male applies the force that rotates the female's abdomen, then the female's participation may be simply the degree to which she resists the force applied by the male.

48. *Dislodge Male*—The female dislodges a mounted male by walking, running, pivoting, and/or elevating her body repeatedly, causing the male to fall or slide off the female.

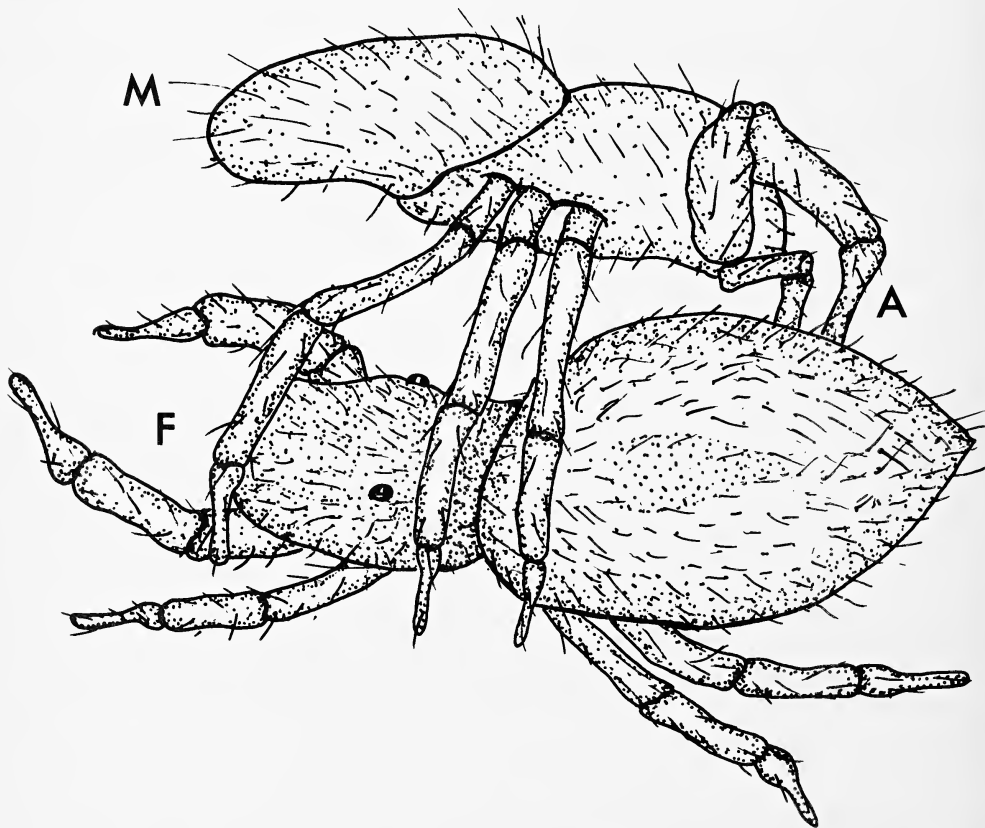


Fig. 10.—Male (M) strokes with his right Leg I (A) while mounted on female (F). Female's abdomen begins to rotate, and her body is lowered.

General Comments on Postmount Behavior—In addition to the described specialized motor patterns, a mounted male may walk and turn on the female's dorsal surface and occasionally groom or stand inactive. During four interactions with subadult females inside nests, mounting occurred. In each case, the male tapped and scraped with his legs, but there was no stroking and the abdomen of the subadult did not rotate. With these exceptions, mounting was not seen during interactions other than ones between males and females.

Crane (1949b) noted that male salticids generally "pat" with their legs and palps after they mount the female. She suggested that the "female's final resistance" is broken down by this behavior, implying that she considers this behavior to be a form of courtship. It would be of value to investigate whether there are species-specific differences in the postmount courtship of different salticid species.

ORGANIZATION OF BEHAVIOR DURING INTERACTIONS

Categories of Behavior—Data concerning the manner in which behavior is organized during various types of interactions are presented in Figs. 11-21. Most of the listed categories are rather broad, and some of these need clarification. Generally each category refers to a period during which the spiders engage predominantly in the activity indicated, regardless of the amount of time that elapses and regardless of whether there are interspersed periods of inactivity, grooming, or other activities that are not included in the figures.

"Display" indicates periods during which the male performs any type of erected or hunched legs display. For example, a male may alternate between performing linear and zigzag dancing. When the female performs behavior such as striking and lunging while a male displays, this is not indicated separately but considered to fall under the category "display." Also, periods during which the male stands or walks without displaying for a few seconds or less sometimes occurred interspersed within episodes of "display."

"Watch and Follow" is treated as a single category. Generally when one occurs both occur, with frequent alternation. The category "decamp" did not include instances in which the spider walked away for only a few seconds, then faced the other spider and began displaying or watching.

When one spider occupies a nest, "Type 2 Courtship" refers to intervals during which the male probes, tugs, or vibrates. Female behavior such as pulling on the nest and bumping may occur also. There may be intervals, sometimes several minutes in duration, during which the male walks, stands inactive, grooms or even feeds on a fly, while standing on the nest. These intervals are not specified, and they were always preceded and succeeded by type 2 courtship. "Type 1 Courtship" refers to episodes of displaying, embracing, or both. Also any intervening intervals of watching and following are not specified.

Considering interactions in which both spiders are outside nests, after the male mounts he may dismount or he may be dislodged. Often the male immediately mounts again without displaying or embracing. These cases are not specified. That is, "mount" includes any number of repeated instances of the male mounting the female, as long as none of the other categories in the figures intervene. Similarly, embracing spiders may move apart momentarily then embrace again. If no other specified category of behavior intervenes, each repeated embrace is included under the single category "embrace."

Considering spiders inside nests, the category "mount" includes not only instances in which the male immediately mounts again after dismounting or being dislodged, but any behavior or period of inactivity after the first time the male mounts, as long as behavior belonging to one of the other designated categories does not occur. Not only can the male mount repeatedly, but there can be periods of spinning, grooming, or standing inactive while not mounted. Similarly, for cases in which females occupy nests, "mate" refers to the time from when the male begins copulation for the first time until one of the other designated categories of behavior occurs. During this time, the male may repeatedly dismount, become dislodged, or spend considerable periods of time, sometimes lasting several hours, spinning, standing, and walking in the nest.

Categories referring to one spider remaining at a nest after the other spider decamps include remaining on the exterior of the nest or remaining inside the nest. A spider on the exterior of the nest frequently enters the nest later.

Beginning of Interactions—For males encountering females outside nests, the beginning of an interaction was defined as the time when the male initiated his first erected legs display. In two interactions (Fig. 11, 0.1%) the female leaped toward and contacted the male, who was not facing the female at the time. Subsequently the male turned and faced the female, embracing followed briefly, then the spiders backed away and the male displayed. The beginning of these interactions was defined by the embrace. Using these definitions, interactions rarely failed to occur when males and females were placed together in the same cage. In a few cases one spider killed and ate the other before an interaction began. On other few occasions a somewhat arbitrary decision was made to remove the male after a considerable time had elapsed during which there was no courtship. In most of these cases, the male was simply inactive. More rarely the male was somewhat active, faced the female several times, but failed to court. There was no set procedure regarding when to remove the male and count such tests as unsuccessful, but a minimum of 60 min elapsed in all cases.

The beginning of an interaction was defined in the same way for males encountering subadults or males outside nests. With one exception, an interaction occurred each time a pair of spiders were placed together. The exception was an encounter between a male and a subadult male in which the male was mostly inactive for 90 min, although the two spiders faced each other once for 15 sec with neither performing a display, followed by both decamping.

In 20 cases each, encounters were staged between two females, two subadult females, or a female with a subadult male (subadult introduced into the cage of the female) with both spiders outside nests. A different definition for the beginning of the interaction was used, since erected and hunched legs displays are infrequently performed by spiders other than adult males. In each case the two spiders were kept together in a cage for 30 min. The beginning of an interaction was defined as the time when the two spiders faced each other (4 cm or less apart) while both were active (walking, waving legs, waving palps, etc.). Using this definition, interactions occurred for 13 female-female, 8 subadult-subadult, and 5 female-subadult male pairs. The latter two will not be discussed further because in each interaction the two spiders simply decamped after facing each other, without performing any of the motor patterns listed in Table 1.

When one spider occupied a nest, the beginning of the interaction was defined as the time when the other spider either touched the nest or when the two spiders faced each other with one occupying the door and the other initiating an erected or hunched legs display. When the spider departed its nest before an interaction began, the other spider

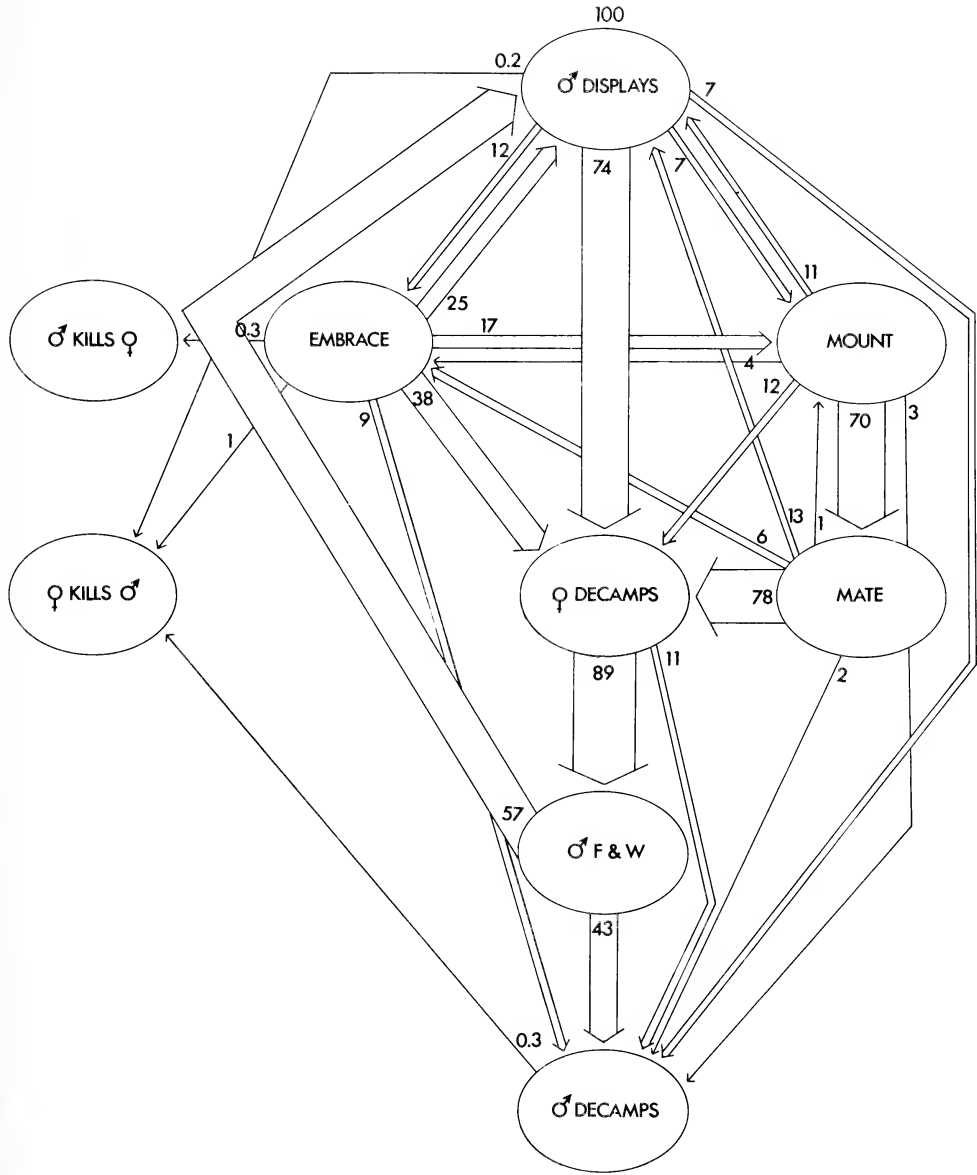


Fig. 11.—Summary of 1335 interactions between adult males and adult females, with both spiders outside nests. No vegetation present. F and W refers to “follow and watch the other spider”. Arrows represent relative frequency (percent) with which preceding category is followed by the indicated following category. Percent of interactions that began with a category is indicated by number written above it. Not in diagram: F and W followed by mounting (0.35) or embracing (0.05), without intervening displays.

was removed. Otherwise the spiders were left together in the cage until an interaction occurred, even if several hours elapsed first.

End of Interaction—When both spiders were outside nests, the end of the interaction was distinct, occurring when the spiders decamped and subsequently avoided each other. In each case, the spiders were left in the cage together for at least 2 min after the interaction terminated. During this time some faced each other, but they did not initiate displays or follow each other, although episodes of watching sometimes occurred. Generally the spiders remained at opposite ends of the cage, walking, grooming, or remaining inactive. Interactions involving a spider inside a nest terminated when at least one spider went away from the nest and the two spiders subsequently avoided each other. Each time, the spiders remained at opposite sides of the cage.

Sometimes during an interaction involving a male outside a nest and another spider inside a nest, an interaction outside the nest transpired after the spider inside the nest departed (Figs. 13, 16, 18, 19 and 20). These usually ended in the same way as other interactions outside nests. In a few cases the spider subsequently entered her nest again and the interaction continued.

Of course whenever one spider killed and ate the other, this event was considered the end of the interaction. Cannibalism was a rare event that will be discussed more fully in a later paper.

Markov Processes—Flow charts of the type depicted here (Figs. 11-21) are most appropriate for Markov processes (Feller 1968), in which the probability of each event depends upon only the immediately preceding event. In some cases, this clearly is not the case. For example, in Fig. 13 mounting and mating sometimes followed type 1 courtship outside nests. When this occurred, females departing nests or evicting males could not follow mating, since the spiders were already outside the nest. However, except for obvious examples of this sort, generally events were not precluded by preceding events. For example, mating may be followed by the female evicting the male who subsequently resumes type 2 courtship and eventually enters the nest again and resumes mating (Fig. 13).

Male-Female Interactions—Although the diagrams depicting organization of behavior tend to be rather complex, some general trends can be abstracted.

Both Outside Nest—For male-female interactions outside nests (Fig. 11) the overall trend is for the male to display followed by the female decamping and the male watching and following the female. A male that is watching and following is approximately equally likely to decamp himself or to initiate erected legs displays again. Less often, a displaying male may embrace, after which the female may decamp or the male may mount. Sometimes a displaying male mounts without first embracing. Mounting tends to be followed by mating, which tends to be followed by the female decamping. On rare occasions, mounting was not immediately preceded by either embracing or displaying. Display or embrace always immediately preceded the first mount during an interaction and each mount that was followed by copulation; and display was usually the event preceding embrace. It was relatively rare that the male decamped before the female decamped.

Female Inside Nest—For interactions between males and females occupying nests, there seem to be several major trends (Fig. 13). A male performing type 1 courtship with the female at the nest door is most likely to switch to type 2 courtship, although it is fairly probable that he will decamp. A male performing type 2 courtship is approximately equally likely to switch to type 1 courtship, with the female at the door, decamp, or enter the nest. The female frequently departs the nest when the male enters, but there is a

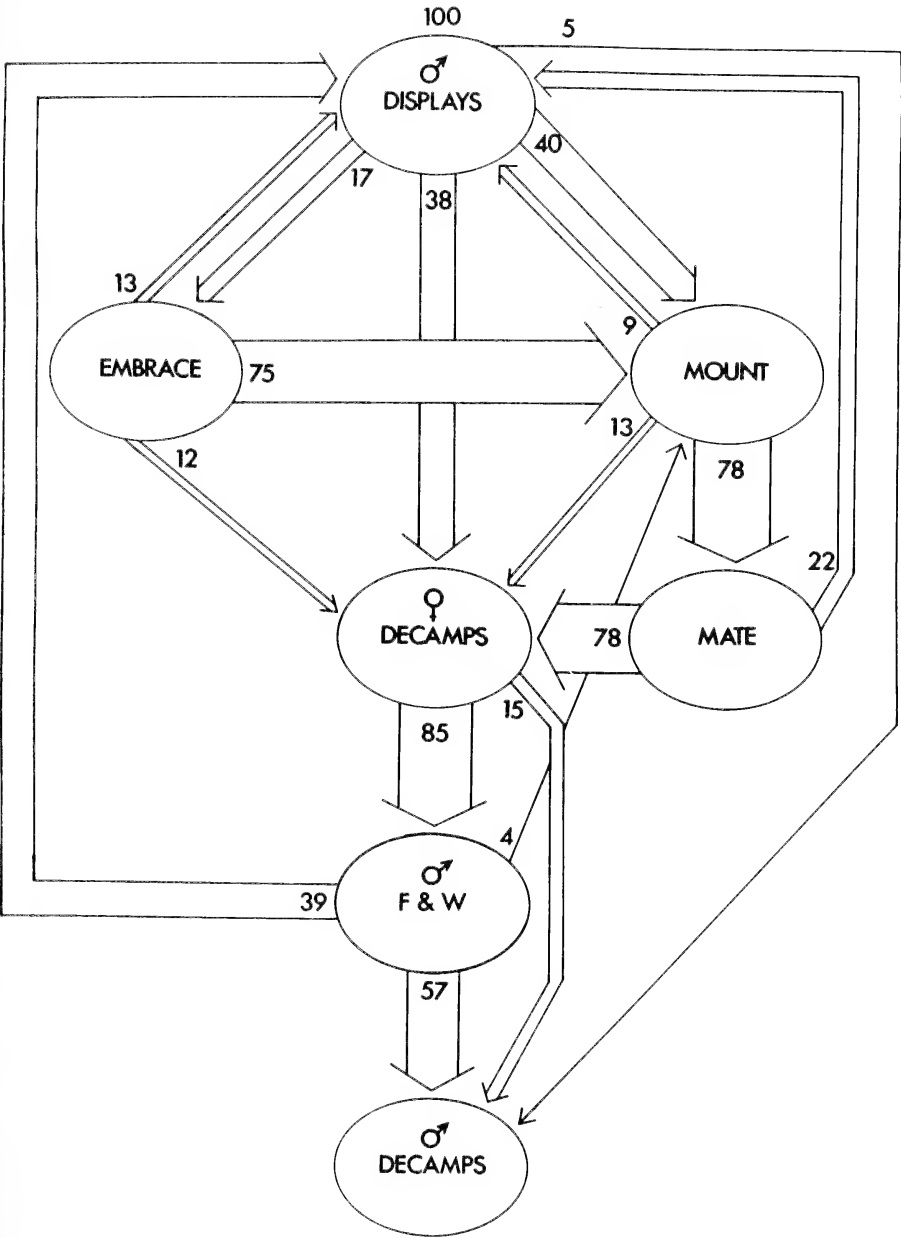


Fig. 12.—Summary of 23 interactions between adult males and adult females, with both spiders outside nests. Vegetation present. F and W refers to “follow and watch the other spider”. See Fig. 11 for explanation of arrows and numbers.

stronger trend for mounting to follow, which is usually followed by copulation. After mating, the female often evicts the male. The evicted male may decamp, although more often he resumes type 2 courtship. The most likely event after mating is for the female to depart the nest, followed by decamping, with the male remaining at the nest.

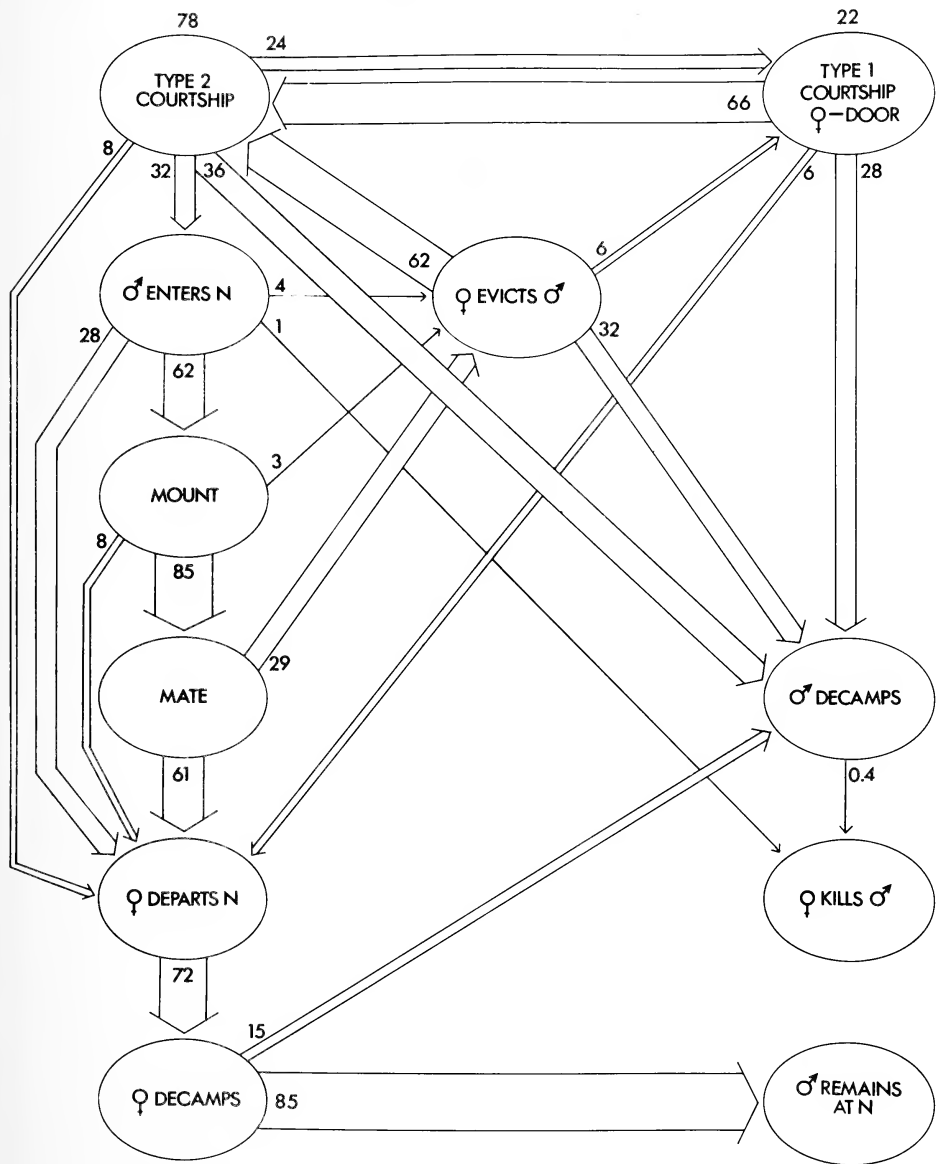
It is noteworthy that type 2 courtship always preceded entering the nest by the male, even when he was entering for the second or later time during an interaction. Females rarely departed their nests unless the male first entered. On a few occasions the male departed the nest after the female departed; type 1 courtship outside the nest ensued; and the male mounted, and sometimes mated. Occasionally females entered their nests again after departing. Usually the female did not go more than 2 cm from the nest before she entered again, and often she spent most of the time on the exterior of the nest. The few cases in which the female went farther from the nest before re-entering were all instances in which type 1 courtship with both spiders outside the nest occurred. In a few cases, copulation inside the nest occurred after the female re-entered. There were some cases in which mating occurred during individual interactions with the female both inside and outside the nest.

Males rarely departed nests occupied by females. When females departed their nests and decamped, most males remained inside the nests. Even on the relatively infrequent occasions when females departed their nests and decamped while the male performed type 1 or 2 courtship, the males tended to remain at the nest, usually eventually entering the nest. The adaptive significance for the male in remaining at the nest after the female decamps is a question of interest. In those cases in which copulation preceded, males may use the nest as a location for sperm induction (Montgomery 1910). Another explanation is needed for males that did not copulate. Perhaps females tend to return to their nests after they decamp, presenting the male with additional opportunities to mate. This possibility was investigated. In 25 cases when the female decamped and the male remained at the nest, the spiders were left together for two hours afterwards. In 19 cases the female did not approach closer to the nest than 5 cm. The other 6 females faced the male at least once while he occupied the door, 1 to 5 cm away. Each female decamped almost immediately and the male remained in the nest. Two of these females also walked onto the nest. In each case, the male became active inside the nest and the female immediately decamped. In all 25 cases, the male remained at the nest for the full two hours. Further

Fig. 13.—Summary of 361 interactions between adult males and adult females, with females initially inside nests. Regular light. N refers to nest. See Fig. 11 for explanation of arrows and numbers. Not in diagram: Male departs nest after entering, without mounting intervening (4). Sometimes if female already outside nest when male enters, followed by female decamping (1). Male departs nest followed by male decamps (25), type 2 courtship (9) or female departs nest (3). Sometimes if female already outside when male departs, followed by type 1 courtship with both spiders outside nest (38) or female decamps (25). Type 1 courtship with both spiders outside nest, followed by male decamps (33), female decamps (33), mount (24) or female re-enters nest (10). Female re-enters nest followed by type 2 courtship (50), type 1 courtship (female occupies door) (10) or female departs nest (10). Sometimes if male inside nest when female enters, followed by female evicts male (30). Mount followed by male departs nest (3). Sometimes if spiders outside nest at time, followed by female re-enters nest (1). Mating followed by male departing nest (5). Sometimes if spiders outside nest at time, followed by female re-enters nest (3), female decamps (1) or male decamps (1). Female departs nest, followed by male departs nest (16) or female re-enters nest (4). Sometimes if male outside nest at time, followed by type 1 courtship with both spiders outside nest (6), mounting (no intervening displays) (1) or male enters nest (1).

observations carried out over longer time intervals and especially ones under field conditions would be valuable. In the field, *P. johnsoni* tend to depart and return to the same nest, and in the laboratory they generally returned to their nests by evening (Jackson, unpubl. data). Possibly if the male remains in the female's nest until evening there is a substantial probability of mating with the female when she returns. The available data are not adequate to evaluate this hypothesis, since these observations were carried out in the morning and early afternoon.

Influence of Environmental Complexity—The normal environment of *P. johnsoni*, containing rocks, vegetation and so forth, is more complex than the relatively bare cages in which the spiders were observed in the laboratory. Observation of spontaneously



occurring courtship in the field was a rare event. On only 3 occasions, a male was discovered while he was displaying near a female. In two cases, the spiders decamped as I approached. In the other cases, I noticed the spiders early enough so that I was able to approach cautiously. The female watched the male as he alternately gestured and postured, without dancing. The male slowly and intermittently approached the female. When the female decamped, the male followed briefly, then he decamped. On other occasions, courtship was "staged" in the field. Ten males were captured in the field. Upon finding females outside nests, males were released one at a time in their vicinity. In 8 cases the spiders decamped without courting. In another 2 cases the male performed erected legs displays as the female watched. No dancing was observed. One female struck once at the male. In each case, when the female decamped the male followed. One male followed only briefly then decamped. For the other male there were four episodes of erected legs displays, each preceded by an episode of following and watching.

The influence of more complex environments on courtship was investigated further using laboratory spiders. Eleven pairs were observed in 56 X 53 X 30 cm (length X width X height) clear plastic terraria. Each terrarium contained a *Coleus* plant growing in a flower pot. With the lid on the terrarium, the leaves and stems were pressed down, filling the terrarium with a meshwork of vegetation. Another 12 pairs were observed in field cages made from clear plastic boxes (30 X 15 X 9 cm), open at the top and bottom. By spreading mineral oil over the sides of the cage, the plastic was made slippery, and the spiders could not climb the sides. These cages were placed over grass covered ground in the field. Any grass that touched the sides of the cage was cut with scissors. Any openings to the outside at the bottom of the cage, resulting from the irregularity of the ground surface, were filled with sand. Three rocks, approximately 6 cm long each, were placed inside the cage.

Since the data from the 2 procedures were similar, they were pooled (Fig. 12). Males were observed to employ erected legs displays, including linear and zigzag dancing. Females performed striking, embracing, and erected legs displays. As in the bare cages (Fig. 11), periods of display behavior alternated with periods of the male following and watching the female (Fig. 12). To approach or follow a female, the male often had to leap across gaps in the vegetation or make detours. Often a male would display while standing on one leaf, while the female watched from another leaf. Sometimes the male stopped displaying, walked away from the female and down the stem, crossed to another stem, then approached the female and displayed when the female faced him again. Except for these differences, the patterns in Fig. 11 and 12 are very similar, and it does not seem that the absence of vegetation introduced major distortions into the portrayal of type 1 courtship that emerged from laboratory studies. The most conspicuous difference between Fig. 11 and 12 is not related to the presence of vegetation. In Fig. 12, displaying and embracing are both followed by mounting more frequently than in Fig. 11, but all females used in interactions involving vegetation were virgins. Virgin females tend to be receptive more often than non-virgin females. Considering only those interactions involving virgin females in cages without vegetation, the transition probabilities for displaying and mounting (23%) and for embracing and mounting (41%) were relatively large compared to Fig. 11 also.

Interactions Under Dim Light—In a study of the sensory modalities employed during type 2 courtship (Jackson 1977), interactions between males and females inside nests were observed under red light, a condition under which *P. johnsoni* do not respond to visual stimuli. The organization of behavior during these interactions is depicted in Fig.

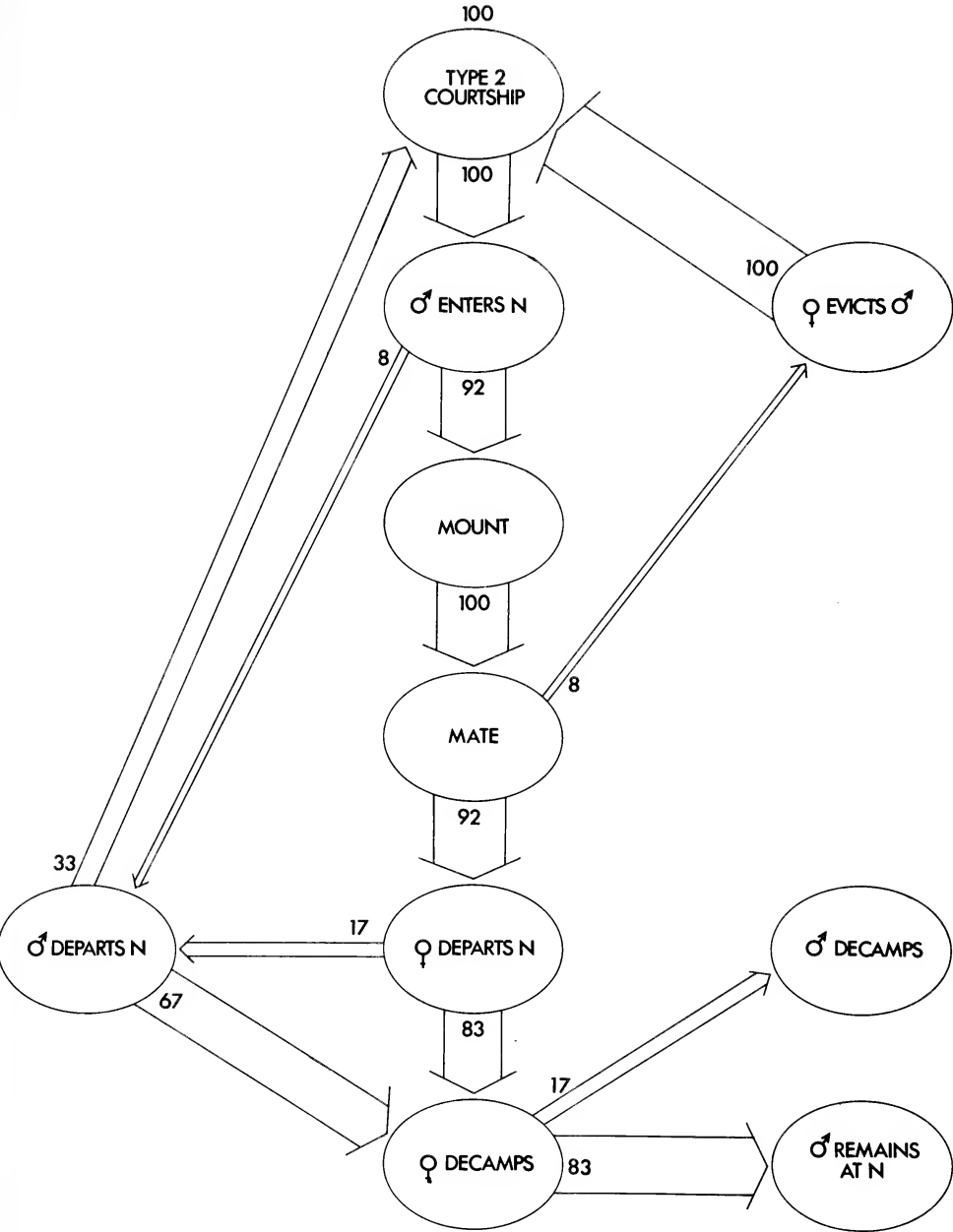


Fig. 14.—Summary of 12 interactions between adult males and adult females, with female initially inside nest. Red Light. N refers to nest. See Fig. 11 for explanation of arrows and numbers.

14. During the observations on which Fig. 13 is based, the spiders were kept under the same laboratory light conditions as during observations with females outside nests. In the field, nests are normally located in dark surroundings, such as under rocks. In this sense, the observations under red light were more realistic.

One major contrast between Fig. 13 and 14 is the relatively large probability of entering the nest after type 2 courtship and the large probability of mounting and mating occurring once the nest is entered in Fig. 14. It would seem that this is related primarily to the fact that all females observed under red light were virgins and consequently very likely to be receptive. When interactions under regular light with only virgin females inside nests are considered the transition probability for entering nest and mounting (87%) and for type 2 courtship and entering the nest (59%) are relatively large compared to those in Fig. 13.

The most important difference when interactions under red light are considered is that all categories of behavior involving type 1 courtship are absent. Type 1 courtship with the female occupying the door was especially common under well-lighted conditions (Fig. 13). This in particular is probably a laboratory artifact. The elimination of this category as a possibility to follow "type 2 courtship" probably contributed toward increasing the probability of entering the nest following type 2 courtship under red light (Fig. 14). Type 1 courtship with both spiders outside nests might occur in the field if the female departs the nest and decamps into brighter surroundings, such as the top of the rock, followed by the male.

In the field, males were sometimes discovered on nests containing females. Usually the male decamped when the rock, under which the nest was located, was overturned. However, on six occasions, males courted briefly at the exposed nest. Probing (both at the door and at other locations), vibrating, and pulling on the nest were observed.

Male-Male Interactions—Interactions involving combinations of spiders other than males and females tend to be organized more simply. When two males interacted while both were outside nests, there were two major trends (Fig. 15). The spiders always initially displayed while facing each other. This was approximately equally likely to be followed by either embracing or by one male decamping. Episodes of embracing tended to alternate with episodes of further displaying, or to lead to one male decamping. When one male decamped, the other male usually followed and watched briefly then decamped. Sometimes the males prodded as they followed decamping males. Interactions between males differed from those between males and females (see Fig. 11 and 12) in that "Follow and Watch" was relatively infrequently followed by more displaying.

The trend during interactions in which a male encountered another male inside a nest was for the intruding male to walk on the nest (Fig. 16), whereupon the resident male comes to the door and the males display. Usually the resident male subsequently departed the nest and there were displays with the two spiders outside the nest, not differing in any important way from other interactions between males outside nests except that the winner frequently remained at the nest. After the last episode of displaying or embracing, the spider that decamped first is defined as the "loser" and the other spider is defined as the "winner". It would be useful to observe interactions between males at nests under red light, eliminating the possibility of display behavior.

Male-Subadult Interactions—When a male encounters a subadult spider outside a nest (Fig. 17), the trend was for the male to display, followed by the subadult decamping with the male following and watching, after which he decamped. Occasionally there were episodes of embracing. In contrast to interactions with females (Figs. 11 and 12), males

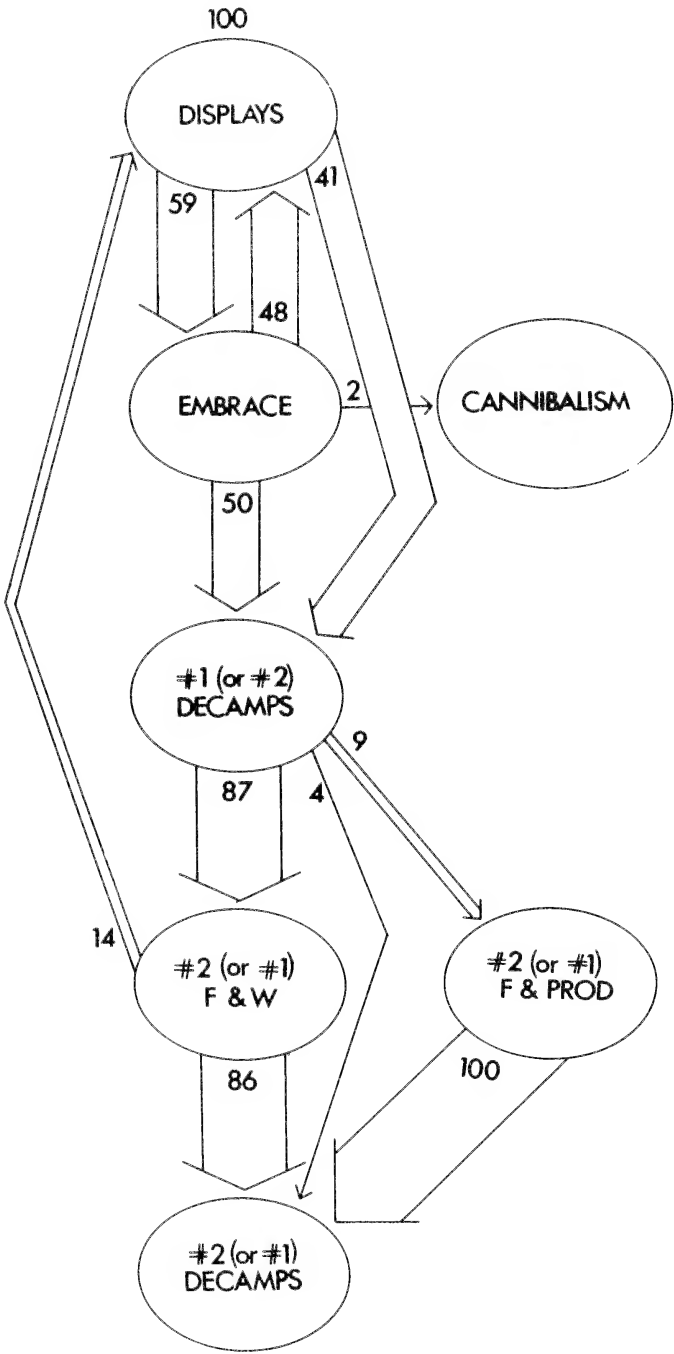


Fig. 15.—Summary of 60 interactions involving pairs of adult males, with both spiders outside nests. F and W refers to “follow and watch the other spider”. The two spiders referred to as #1 and #2. See Fig. 11 for explanation of arrows and numbers.

usually did not display again after following and watching a subadult. Since interactions involving subadult females (40) and those involving subadult males (19) did not differ in any important ways, the data are pooled.

Interactions with the subadult inside a nest (Figs. 18 and 19) were basically similar regardless of whether the subadult was a female or male, except that cohabitation never occurred with subadult males. The trend was for the males to court on the nests, followed

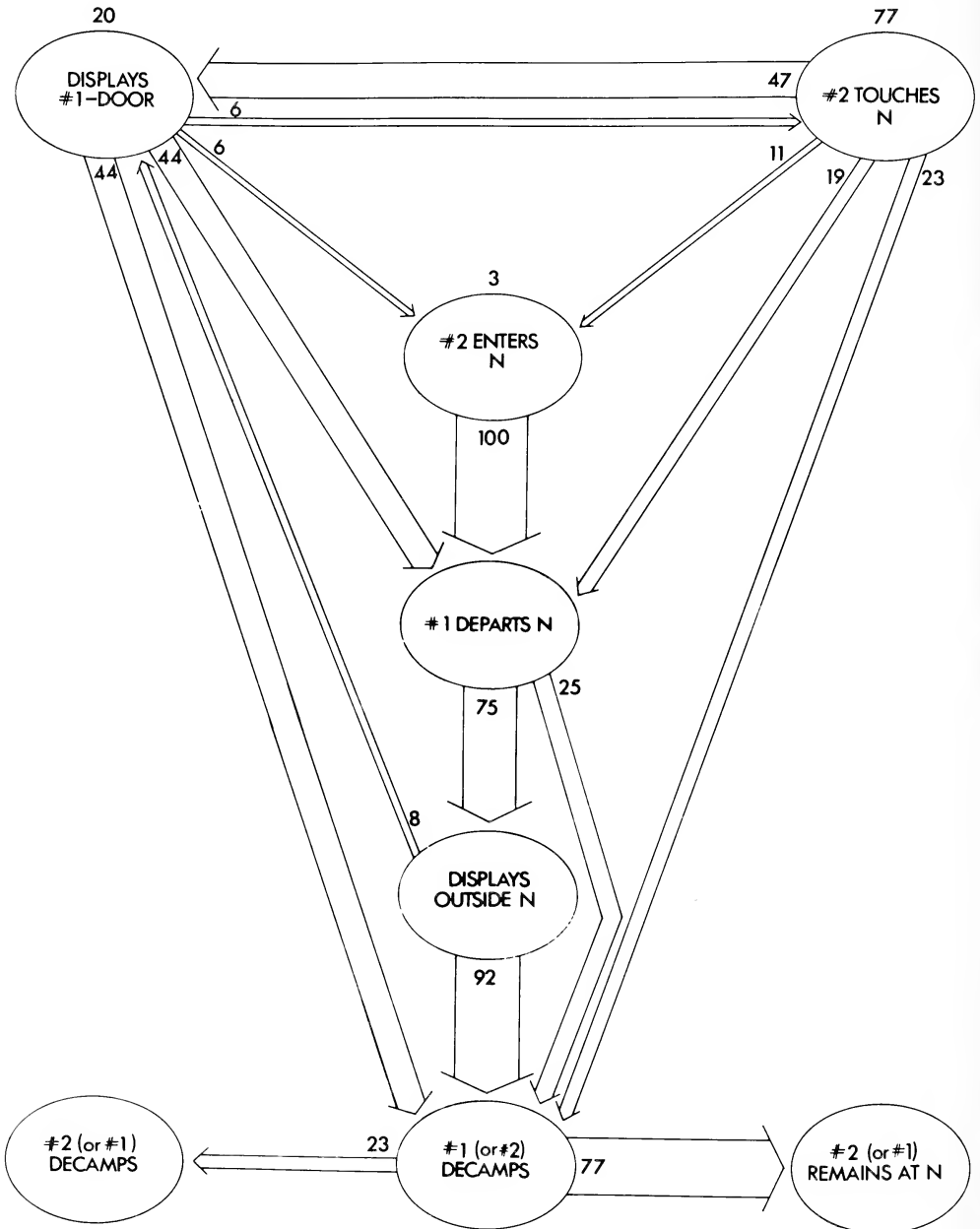


Fig. 16.—Summary of 30 interactions involving pairs of adult males. Initially, male #1 inside nest and #2 outside nest. N refers to nest. See Fig. 11 for explanation of arrows and numbers.

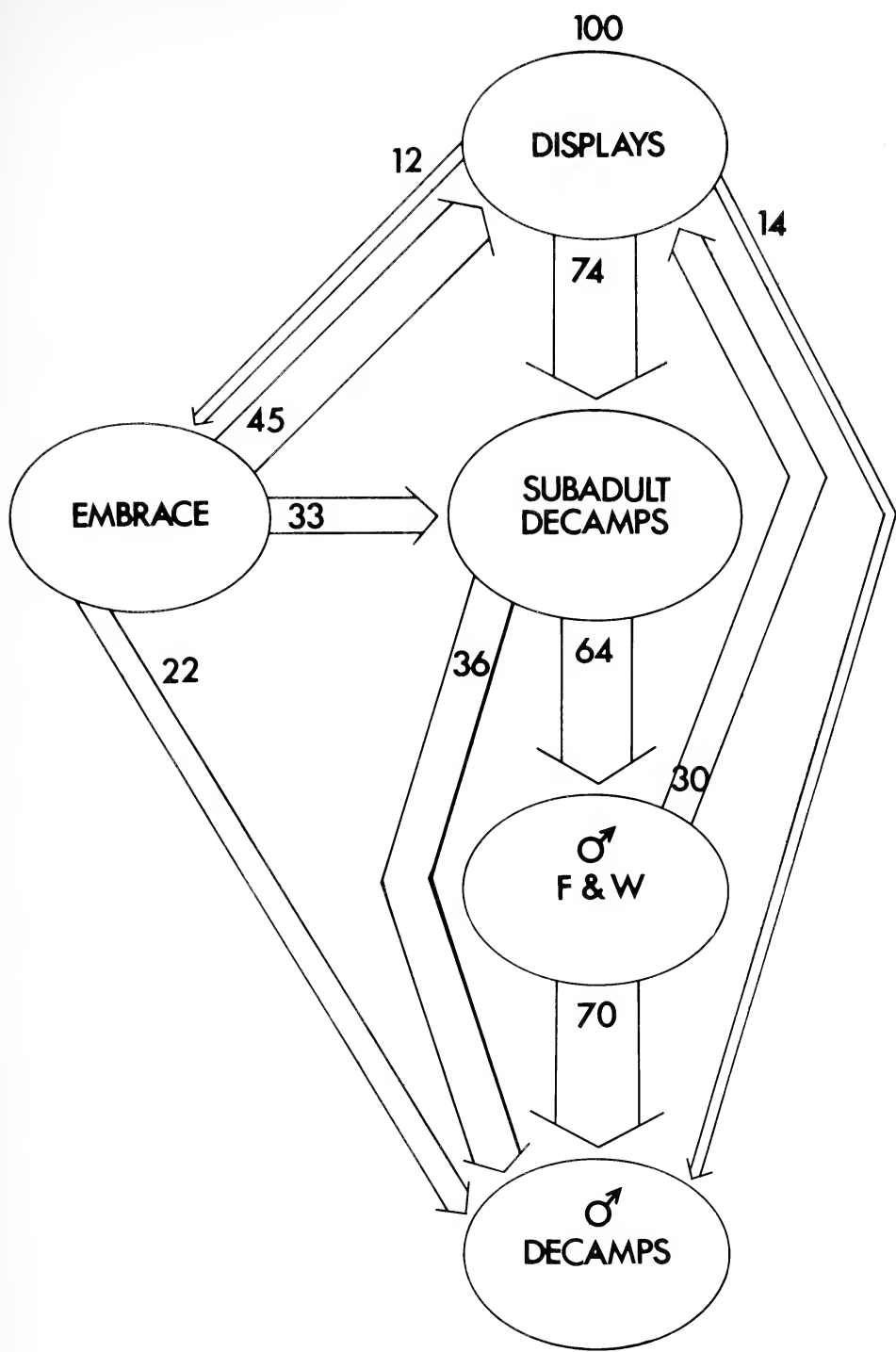


Fig. 17.—Summary of 59 interactions between adult males and subadults, with both spiders outside nests. Data for subadult males and subadult females are pooled. F and W refers to “follow and watch the other spider”. See Fig. 11 for explanation of arrows and numbers.

by the subadults departing the nests and decamping with the male remaining at the nest. Compared to interactions involving adult females, males rarely entered nests. Subadults compared to females were very prone to depart the nest.

Subadult-Female Interactions—Since interactions in which subadults encountered females inside nests were organized in a relatively simple manner, the relevant data will be given here rather than in a figure or table. Since data for subadult females (20) and subadult males (17) were similar, the data will be pooled. Each interaction began in one of four ways; (a) The subadult touched the nest (26). This included cases of walking onto the nest, cases of touching the nest with the forelegs only, and instances in which the subadult placed its forelegs inside the nest door. In two cases, the subadult entered the nest then quickly departed and decamped. In another three, the female came to the door and displayed, whereupon the subadult decamped. Decamping by the subadult followed

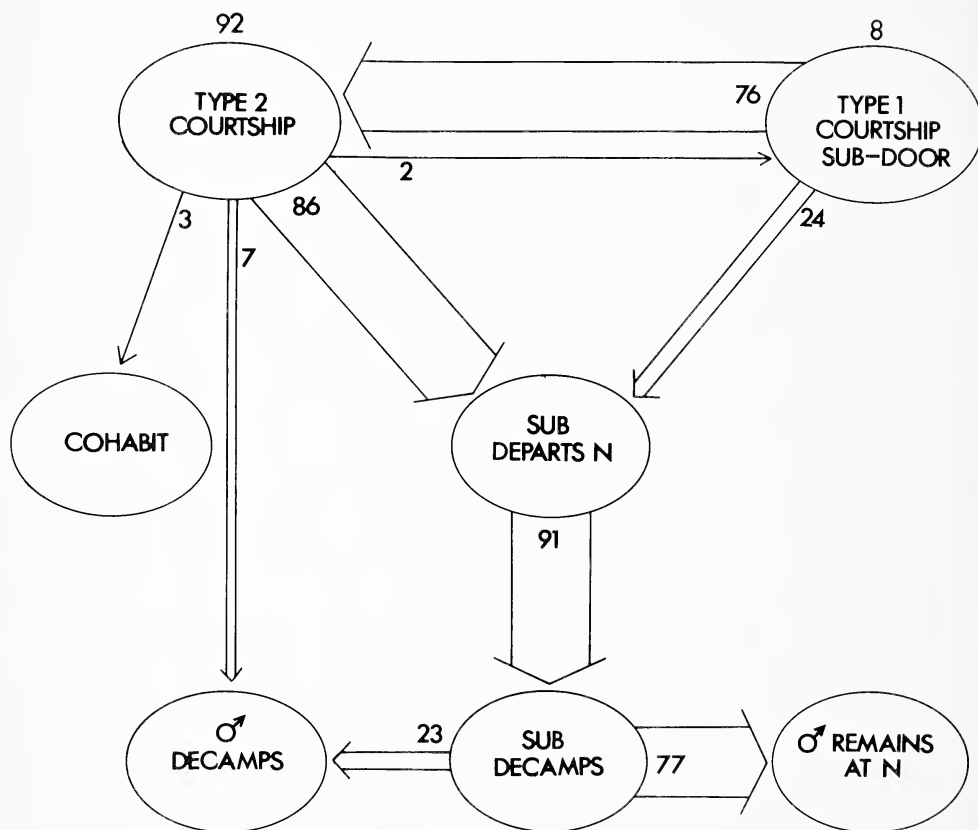


Fig. 18.—Summary of 156 interactions between adult males and subadult females, with subadults initially inside nests. N refers to nest. See Fig. 11 for explanation of arrows and numbers. Not in diagram: Type 2 courtship, followed by male enters nest (2). Male enters nest, followed by male departs nest (72), subadult evicts male (14) or subadult departs nest (14). (In each case, when male departs nest subadult already outside nest.) Male departs nest followed by type 1 courtship with both spiders outside nest (75) or subadult decamps (25). Subadult departs nest followed by type 1 courtship with both spiders outside nest (5), male enters nest (3) or subadult re-enters nest (1). Type 1 courtship with both spiders outside nest followed by subadult decamps (78) or subadult re-enters nest (22). Subadult re-enters nest followed by type 2 courtship (80) or type 1 (subadult occupies door) (20).

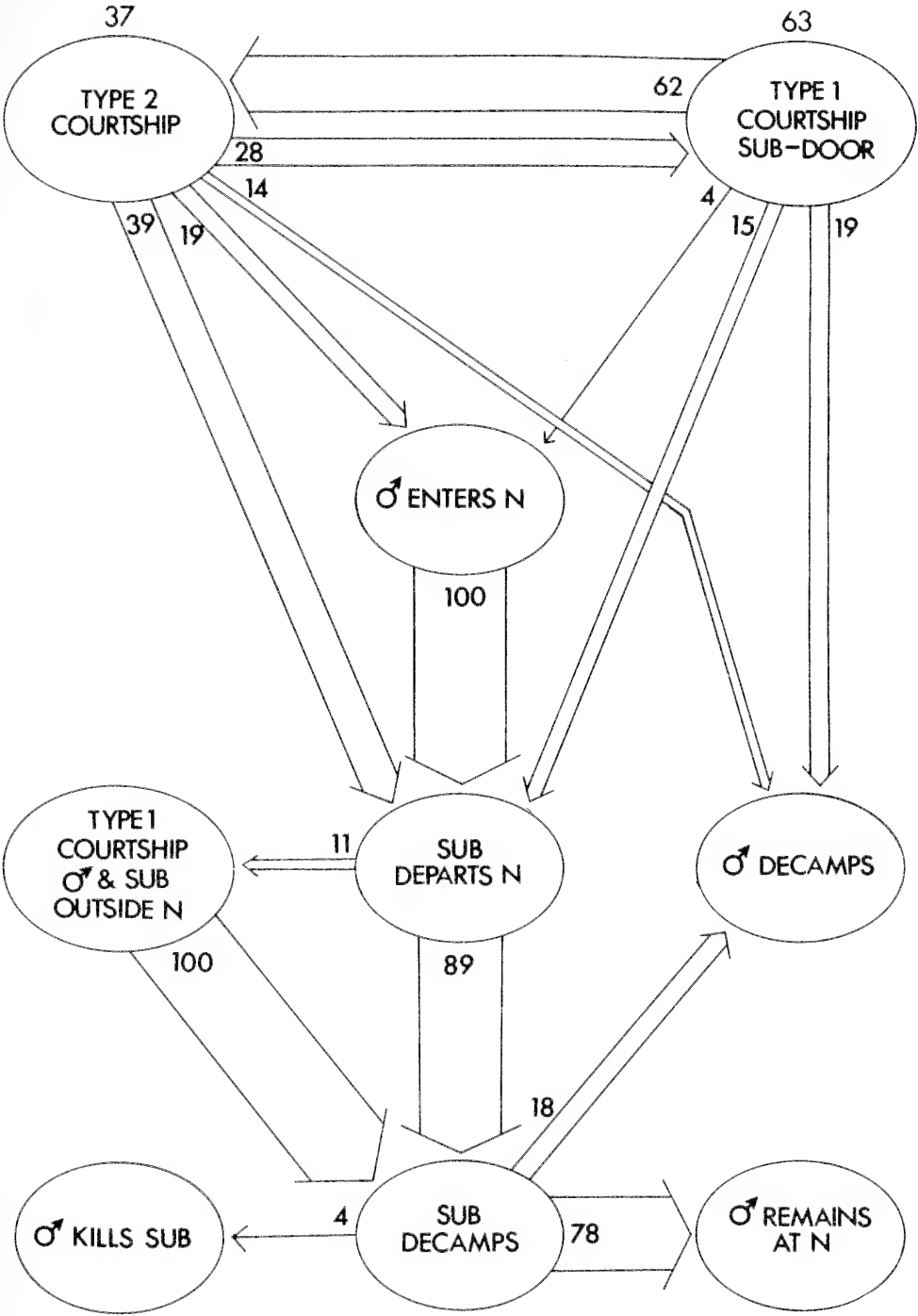


Fig. 19.—Summary of 27 interactions between adult males and subadult males, with subadults initially inside nests. N refers to nest. See Fig. 11 for explanation of arrows and numbers.

more quickly in the remaining cases. (b) The subadult and female faced each other, with female occupying the door, whereupon one or both displayed (7). (c) The subadult walked past the nest door, whereupon the female struck from the door (2). (d) The female departed the nest and slowly approached the subadult who was walking in the

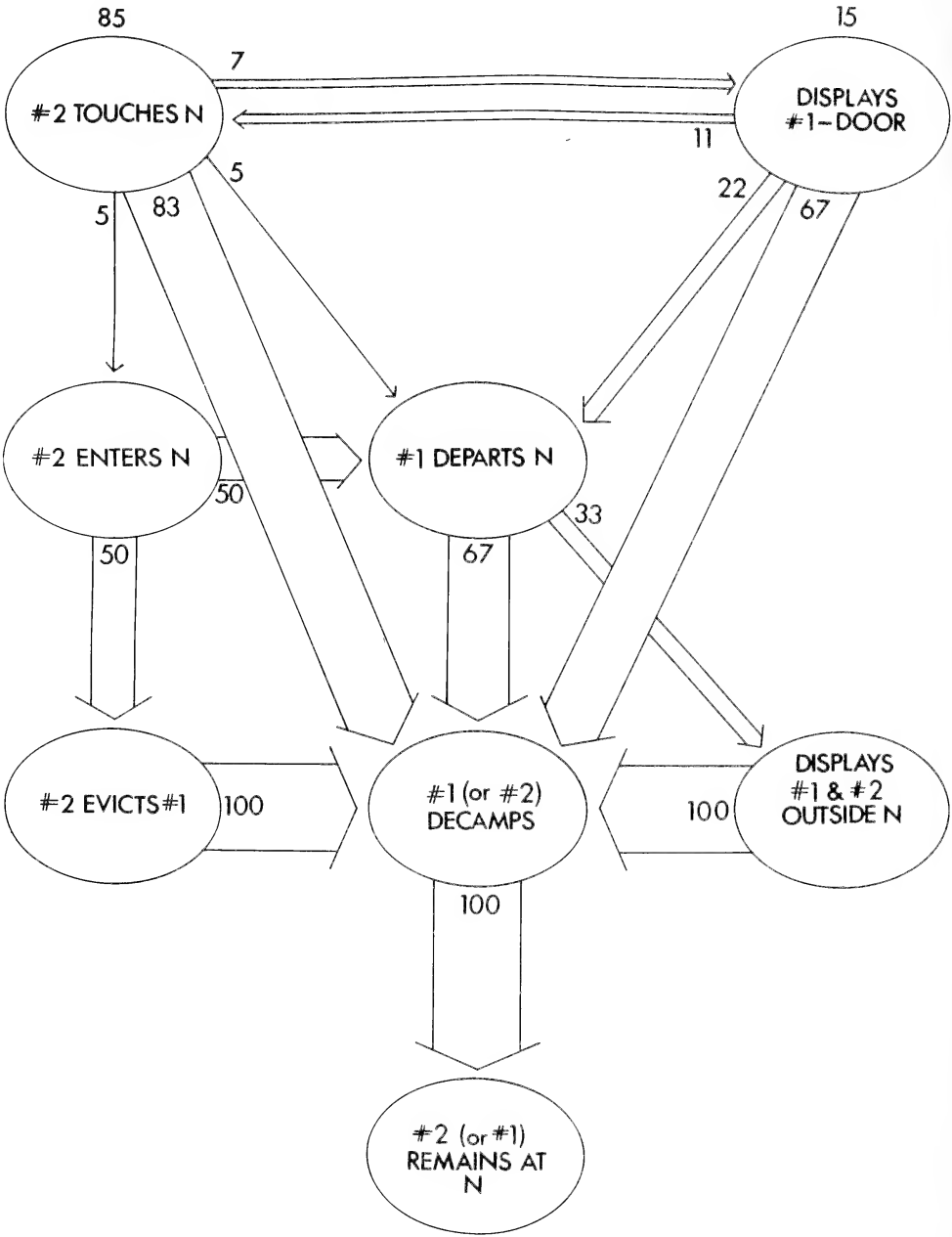


Fig. 20.—Summary of 47 interactions involving either pairs of adult females or pairs of subadults. Initially, spider #1 inside nest and #2 outside nest. N refers to nest. See Fig. 11 for explanation of arrows and numbers.

vicinity; the subadult faced the female then decamped, followed by the female decamping, with neither spider displaying (2). Except for these last two instances, the female always remained at the nest after the subadult decamped.

Female-Female and Subadult-Subadult Interactions—Interactions involving two females (32) and those involving two subadults (15), with one spider inside a nest, were quite similar, and these data are presented together in Fig. 20. In basic respects these interactions resembled ones in which subadults encountered females inside nests. The trend was for the intruder to touch the nest, then to decamp. Rarely, the intruder entered the nest, followed quickly by an eviction or departure. Occasionally, the resident departed the nest and the spiders displayed outside the nest, followed by one spider decamping. When one spider decamped, the other always remained at the nest. Compared to interactions in which a male encountered a female or subadult inside a nest (Figs. 13, 14 and 18), a subadult or female encountering another subadult or female (Fig. 20) inside a nest is more prone to decamp after touching the nest, without entering first and without the resident spider departing the nest first.

Postmount—The organization of postmount behavior is depicted in Fig. 21. Each time a male mounted a female is treated as a separate sample, regardless of whether mounting

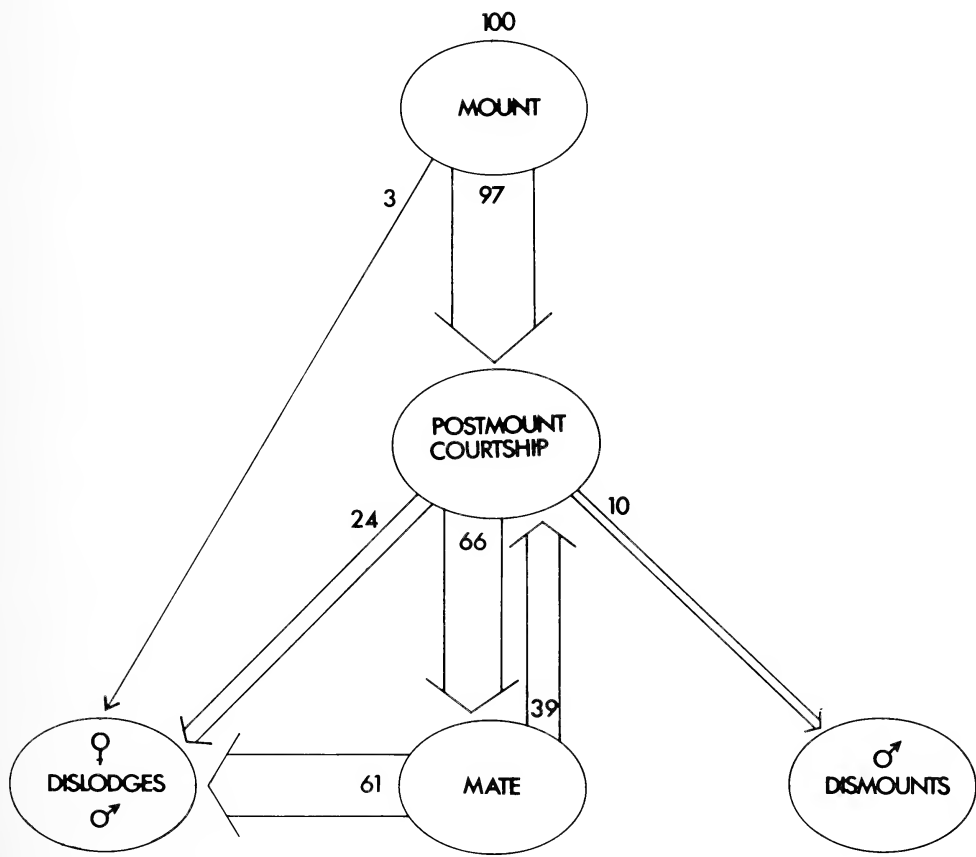


Fig. 21.—Summary of behavior after 331 cases in which adult males mounted adult females outside nests. See Fig. 11 for explanation of arrows and numbers.

had already occurred previously during the same interaction. Postmount behavior involving spiders inside nests proved more difficult to observe and was not recorded in equal detail. However, casual observations provide no indication of major differences. Within the category "postmount courtship", there are five stages that occur in the following sequence; male taps with legs and palps, male scrapes with legs, male strokes, female abdomen rotates, male scrapes with palp. Transition probabilities are not available. However, stages are never skipped, although the female may become active or her abdomen may fail to rotate, in which case the male might return to an earlier stage in the sequence. Copulatory behavior will be the topic of another paper. It will suffice to note here that during one bout of copulation the male repeatedly disengages his palpal organ from the female, followed by application of the same palp to the same side of the female's epigynum or application of the other palp to the other side. During the interval during which the palp is not applied, the female's abdomen rolls back to its normal position. To renew copulation the male always strokes. However, postmount courtship is not recorded in Fig. 20 unless the male returns to the first stage, i.e., tapping with legs and palps.

GENERAL DISCUSSION

The only other descriptions of the courtship behavior of *P. johnsoni* with which I am familiar are those of Dewey (1965). Her analysis is based on 42 interactions involving male-female pairs, 9 involving pairs of males, and an unspecified number involving pairs of females. Considering the relatively few interactions observed, it is not surprising that her descriptions are not highly detailed and that she apparently noticed only a portion of the behavioral elements reported here. For example, she does not distinguish between erected legs displays, hunched legs displays, and legs that are simply raised. Her category "waving legs" seems to include all three. Her photographs, however, show erected legs during an interaction involving a male and a female and hunched legs during one between a pair of males. Zigzag dancing is described, but she apparently did not notice linear dancing. From her descriptions it is apparent that she saw embracing, truncated leaping, and tapping with palps. Other common behavior elements, such as striking and tapping with legs are not mentioned. Consistent with my results, she noted that frequently when a female decamped from a displaying male, the male followed and performed displays again when the spiders faced each other again. Dewey noted that copulation was often preceded by periods of decamping by the female and renewed displays by the male, but she made no mention of periods of display behavior following copulation, a relatively common occurrence during my observations.

Studies based on relatively few observations are of value, and the intention here is not to suggest otherwise. However, I would like to make a case for extensive observation when possible, since comparison of the observations reported here and those reported by Dewey indicate that, as noted by Dane and van der Kloot (1964) and Altmann (1968), a substantially more complete picture of a species' signal repertoire can be gained through increased numbers of observations.

Crane (1949b) concluded that in the salticids there are two major stages in both courtship and threat displays. Species-specific differences and differences between courtship and threat occur in Stage I. Stage II, which occurs immediately before mounting or embracing, is very similar in all species and for both courtship and threat. During this

stage the male's legs I are extended forward and slightly elevated. However, as noted by Dewey (1965), this characterization is not appropriate for *P. johnsoni*. Although the male's legs I are usually extended forward (erected legs position A) immediately previous to mounting a female, his legs I are normally extended perpendicular to his sagittal plane (hunched legs) immediately before embracing during interactions between males. The display behavior of males during interactions with other males tends to be distinct from displays with females throughout the course of the interaction. If Crane's Stage II is taken to be synonymous with posturing with legs in erected legs position A, then Stage II does not normally occur during interactions between males in *P. johnsoni*. Although this behavior occurs frequently during courtship in *P. johnsoni* it is not always a distinct stage, since it often occurs with the spiders many centimeters apart and at times other than immediately before mounting.

The relative rarity of some elements of the communicative behavior of males (e.g., dancing and vibrating) and females (e.g., swaying and stabbing) brings into question the function of these motor patterns. One approach would be to investigate whether these behavioral elements vary in a unidimensional or multidimensional manner (Wiley 1976). Multidimensional variation would be indicated if different components of the communicative behavior of *P. johnsoni* vary independently and convey information about different variables related to the performer's situation or tendencies (Wiley 1975). On the other hand, variation might be unidimensional with nested components. Different elements of behavior might have different thresholds for response to the same internal variable. In this manner, the performer presents qualitatively different arrays of stimuli, correlated with differing intensities of some internal variable. This would presumably enhance the recipient's discrimination of the performer's intensity level with respect to some internal factor (Wiley 1976). Further research is needed to resolve these questions.

As noted by Dewey (1965), the patterning of courtship acts in *P. johnsoni* is complex (see Figs. 11, 13 and 18). Data were not collected concerning finer points of organization, such as alternation by males between different types of erected legs displays during type 1 courtship and alternation between probing, tugging, and vibrating during type 2 courtship. However, my impression is that organization at this level is highly variable. The complexity of organization and the inclusion of numerous distinct signals, some of which are relatively rare, may be related to a selection pressure for a degree of non-predictability and novelty (Barlow 1968, Hartshorne 1958). Reducing monotony and the potential for habituation would seem especially important during type 2 courtship, which frequently involves interactions that persist for many hours, compared to type 1 courtship which usually persists for only a few minutes (Jackson 1976). However, during interactions not involving nests, a male that fails to maintain the female's attention and arousal probably runs a greater risk of losing contact with her, compared to a male courting a female inside a nest, since females inside nests are less prone to decamp (Jackson 1976, also compare Fig. 11 and Fig. 13). Thus, during both types of courtship, it would seem to be considerably to the male's advantage to maintain the female's attention.

Reviewing published descriptions for mammals, birds, and fish, Moynihan (1970) noted that the usual range of major displays in the repertoire of adults of a single species seems to be from approximately 15 to 35. Moynihan used the expression "display" for all signals, regardless of the sensory modality involved. Although no explicit rules were provided for deciding when signals should be considered "major," this qualification is related to the signal being distinct from others and not part of a continuum with other

signals. An estimate will be provided here for the number of major signals in the communicatory repertoire of *P. johnsoni*. In type 1 courtship the major signals of males are linear dance, zigzag dance, gesture without dancing, posture without dancing, and embrace. In type 2 courtship the major signals of the male are probe, tug, vibrate, spin mount, and embrace. In aggressive interactions with other males the major signals of the male are pose, wag, embrace, and prod. During postmount courtship the major signals of the male are tap with legs and palps, scrape with legs, stroke, and scrape with palp. The major signals of the females are posture without dancing, strike, lunge, truncated leap, charge, sway, and embrace, when outside nests. When inside nests, they are strike, embrace, pull on nest, bump, and stab. There are 16 major signals of the males, 10 of the females, and 24 different signals when the sex of the spider is ignored. Although this is only a tentative estimate that could be altered if some of the presumptive signals such as scrape with palp, are found to serve exclusively mechanical functions, it is noteworthy that the estimated number of major signals is within the usual range for mammals, birds, and fish. Moynihan (1970) did not consider invertebrates and raised the question of whether they would conform to the same trend as the vertebrates that he reviewed. Judging from the data concerning insects reviewed by Wilson (1975) and the estimate made here for *P. johnsoni*, the trend seems to hold for the arthropods.

Moynihan (1970) argued that selection against greater numbers of major signals is related primarily to the disadvantages of excessive heterogeneity in appearance. There may be a point at which heterogeneity ceases to be advantageous due to overcoming monotony and becomes disadvantageous through causing confusion or by being "startling."

A final point that bears comment is the relatively frequent occurrence of interactions during which females decamped then later copulated (see Fig. 11). This behavior on the part of the female is subject to various interpretations, that will be discussed in a later paper on sexual selection. Here I will simply note some possible advantages to the female that have been suggested by work with other animal groups: inciting of intermale competition as a mechanism for sexual selection by female choice (Cox and LeBeouf 1977), testing of the male's stamina and persistence (Maynard Smith 1956), prolongation of the interaction as a mechanism that provides increased time to monitor the male's courtship; and direct testing of the male's following behavior as part of a species isolation code (Land and Collett 1974).

ACKNOWLEDGEMENTS

Roy Caldwell, Evert Schlinger, Lennell Jackson, and Charles Griswold contributed valuable assistance during all phases of this study. Also, I would like to thank Jerome Rovner, George Barlow, Peter Witt, Frank Enders, and Robert Yamamoto for valuable discussions and comments on the manuscript. Thanks go to Mary Catharine Vick and Carol Willard for assistance in the preparation of figures and to Rubenia Daniels for typing the manuscript.

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FALSE SCORPIONS OF THE GENUS *APOCHEIRIDIUM* CHAMBERLIN FROM WESTERN NORTH AMERICA (PSEUDOSCORPIONIDA, CHEIRIDIIDAE)

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ABSTRACT

New records, measurements, and morphometric ratios are provided for Chamberlin's western North American species: *Apocheiridium ferumoides*, *A. inexpectum* and *A. mormon*; and descriptions are given for three new species from Oregon: *A. bulbifemorum*, *A. granocheum* and *A. fergusonii*. A key to these six species is included.

INTRODUCTION

The family Cheiridiidae Chamberlin (Superfamily Cheiridioidea Chamberlin) with about one dozen genera from both hemispheres contains some of the smallest pseudoscorpions, with adults ranging in size from 1.0 to 1.8 mm (Vitali-di Castri 1966). The genus *Apocheiridium* Chamberlin, nearly cosmopolitan in distribution (Chamberlin 1931), includes the largest number of described species (Vitali-di Castri 1966) of any genus in the family. Only four species of *Apocheiridium* have been reported from the United States: *A. ferumoides* Chamberlin, *A. mormon* Chamberlin and *A. inexpectum* Chamberlin from the western states, and *A. stannardi* Hoff from the midwestern states. Chamberlin, in erecting the genus in 1924, noted that the four then-known species (*A. ferumoides*, *A. mormon*, *A. ferum* (Simon) and *A. chamberlini* Godfrey) were "superficially very similar" and that "careful examination" was "necessary to distinguish them" (p. 34). This is no less true of the six species, now reported from the western states, since all share many characters in common.

This paper, one of a series resulting from studies originally centered upon pseudoscorpions collected in Oregon, is the first major report of the western species, *A. ferumoides*, *A. mormon* and *A. inexpectum*, since Chamberlin described them in 1924 and 1932. This study, based on the examination of Chamberlin's types and a number of other specimens, new and old, includes: new records, measurements and morphometric ratios for these little-known species, and descriptions of three new species. A key to these six species is provided. Measurements and morphometric ratios of the chela and chelal hand exclude the pedicel, while those of the femur include the pedicel.

GENUS *APOCHEIRIDIUM* CHAMBERLIN

Apocheiridium Chamberlin, 1924:34 (type species, *Apocheiridium ferumoides* Chamberlin); Beier, 1932:10; Hoff, 1952:192, 1958:19; Vitali-di Castri, 1966:379.

Individuals of the genus can be recognized by the following combination of characters (Chamberlin 1924; Hoff 1952; Vitali-di Castri 1966): posterior margin of carapace and tergites without posteriorly projecting tooth-like spurs or serrations, 11 tergites visible from dorsal view instead of 10, movable finger of chela of adult with a single tactile seta, and vestitural setae of body and pedipalps non-clavate. Since the western North American species share so many characters in common, the following generic description is given so that needless repetition can be avoided in the description of the three new species.

Description.—Based only on western North American species, including the type species. Body flat and robust (Chamberlin 1931, figs. 6, 66). Derm coarsely granulate on most surfaces except for smooth areas of sternites, coxae, trochanters of legs, chelicerae and pleural membranes. Investing setae simple and relatively straight to arcuate (Chamberlin 1931, fig. 47), with a single more or less developed submedial spine or tooth. Carapace subtriangular (Fig. 3); derm with rounded to stellate rugosities; one pair of corneate eyes located about three ocular diameter from anterior margin. Abdomen elliptical; derm of tergites heavily sclerotized with rounded to stellate rugosities, inter-tergal and intra-tergal membranes with smaller rugosities or granules; tergal scuta one to nine divided; derm of sternites relatively smooth and membranous, with some areas of pigmented reticulations in posterior and lateral portions of abdomen. Male genital area as illustrated by Chamberlin (1931, fig. 51); female genital area (Chamberlin 1931, fig. 52) with a small pair of long slender lateral cribriform plates and a single median plate, ovoid in shape and three times longer than lateral plates; spermathecae a pair of very long slender tubules with broad, elongate terminal enlargements.

Chelicerae (Chamberlin 1931, fig. 14) small; derm smooth; well-developed lamina exterior; hand with four setae, *b* toothed and *sb*, *is*, *es* simple; flagellum (Chamberlin 1931, fig. 15) of three unequal length blades; movable finger with a well-developed subapical lobe; galea (Chamberlin 1931, fig. 18) of male a broad triangular shaft with one or two tiny terminal rami, of female a series of three long, equal length rami arising individually from finger; serrula exterior with nine to 10 ligulate plates; serrula interior a weakly developed membranous velum; fixed finger with approximately three small marginal teeth.

Pedipalps slender to robust (Chamberlin 1924, figs. Z, AA); derm finely to coarsely granulate, except as noted; coarse granules extending well above the surface, especially on the trochanter and femur, becoming progressively lower and less numerous on tibia and base of chelal hand (number of coarse granules varying according to species); each finger (Chamberlin 1931, fig. 38) with a graded series of low, elongate retrorse teeth, becoming vestigial proximal to midpoint of finger.

Legs (Chamberlin 1931, fig. 44) somewhat stout; derm granulate except for smooth membranous-like surface of trochanters; dorsal surfaces of other podomers with low coarse tooth-like granules similar to those of palps, especially pronounced on femur of leg IV.

Remarks.—No doubt, many of these characteristics are typical of all species of *Apocheiridium*. However, since I have examined type specimens only of western North American species, this description is restricted to those species. Careful measurements must be taken in order to identify these distinctive but similar (appearing) species.

KEY TO ADULTS OF SPECIES OF *APOCHEIRIDIUM* CHAMBERLIN
FROM WESTERN UNITED STATES

- 1. Chela length/tibia breadth ratio of male not more than 4.9, of female not more than 5.22
Chela length/tibia breadth ratio of male 5.5-6.0 and of female 5.4-5.7 and chela length of male 0.43-0.49 mm, of female 0.48-0.53 mm; from Idaho and Oregon *A. mormon* Chamberlin
- 2. Chela length less than 0.42 mm3
Chela length of male 0.44-0.47 mm, of female 0.47-0.54 mm and chela length/tibia breadth ratio of male 4.2-4.7, of female 4.3-4.9; from California and Oregon*A. ferumoides* Chamberlin
- 3. Dorsum of chelal hand with a number of coarse granules, usually intermixed with moderately-sized or fine granules; from Oregon4
Dorsum of chelal hand very finely granulate to smooth, nearly lacking in granules and femur length/breadth ratio of male 4.3-4.6, of female 4.4-4.8; from southern California and Mexico *A. inexpectum* Chamberlin
- 4. Proximal third (exclusive of pedicel) of femur more or less enlarged with medial margin nearly straight, or at most very shallow concavity (Figs. 2,4)5
Proximal third of femur bulging on both margins, markedly on lateral margin and noticeably on medial margin with distinct concavity on both margins distad of proximal "bulge" (Fig. 1); femur length of female 0.33 mm (male lacking) *A. bulbifemorum* n. sp.
- 5. Femur length of male 0.27-0.28 mm, of female 0.27-0.29 mm and chela length of male 0.34-0.35 mm, of female 0.35-0.37 mm *A. granochelum* n. sp.
Femur length of male 0.33-0.35 mm, of female 0.35 mm and chela length of male 0.39-0.40 mm, of female 0.40 mm *A. fergusonii* n. sp.

Apocheiridium bulbifemorum, new species
Figure 1

Specimen examined.—*Type record.* Oregon: Douglas Co.; 13 km S, 6 km E of Tiller (800 m), bark of *Pinus lambertiana* Dougl., 13 September 1973 (E. M. Benedict), 1 female (holotype AMNH).

Etymology.—The specific name is from the latin word *bulbus* which refers to the unusual end enlargement of the palpal femur.

Distribution.—Known only from Douglas County, Oregon.

Diagnosis.—Based on female, male unknown. Body length 1.31 mm, palpal femur length 0.32 mm; proximal third of femur (exclusive of pedicel) markedly bulging on both lateral and medial margins, femur length/breadth ratio 3.9; dorsum of chelal hand with a number of coarse granules intermixed with moderately sized ones.

Description.—Measurements in Table 1, morphometric ratios in Table 6. Carapace with stellate rugosities; chaetotaxy 4-16 (85±). Coxal chaetotaxy ?-2-3:2-4:2-2 or 3:2-4. Abdominal terga with stellate rugosities; chaetotaxy of terga 22:26:22:24:28:28:30:34:32:24:16:mm; of sterna 11:(0)9(0):(0)11(0):14:18?:21:24:19:13:mm. Chelicera typical of genus. Palp (Fig. 1) moderately slender except for enlargement of proximal third of

Table 1.—Measurements (in mm) of two new species of *Apocheiridium* Chamberlin from Oregon (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable)

	<i>A. bulbifemorum</i>	<i>A. fergusonii</i>	
	1 ♀	2 ♂♂	1 ♀
Body L	1.31	1.21-1.33	1.38
Abdominal B	0.72	0.69-0.72	0.76
Carapace L	0.38	0.38-0.40	0.43
Ocular B	0.20	0.21-0.22	0.24
Posterior B	0.50	0.45-0.47	0.52
Eye diameter	0.026	0.019	0.022
Chelicera L/B	0.09/0.05	0.08-0.09/0.05	0.08/?
Pedipalp			
Trochanter L/B	??	?-0.18/0.11-?	0.17/0.11
Femur L/B	0.33/0.08	0.33-0.35/0.08-0.09	0.35/0.08
Tibia L/B	0.27/0.09	0.27-0.28/0.08-0.09	0.29/0.09
Chela L/B	0.40/0.12	0.39-0.40/0.12	0.40/0.13
Hand L	0.18	0.18-0.20	0.22
Movable finger L	0.21	0.20-0.21	0.19
Leg I			
Entire femur L/D	??	0.19/0.07	0.19/0.07
Tibia L/D	??	0.12/0.05	0.10/0.05
Tarsus L/D	??	0.11/0.03	0.10/0.03
Leg IV			
Entire femur L/D	??	0.26/0.06	0.27/0.07
Tibia L/D	??	0.15-0.17/0.03-0.04	0.17/0.05
Tarsus L/D	??	0.11-0.13/0.03	0.09/0.03

femur; derm mostly coarsely granulate intermixed with moderately sized to fine granules; dentition appears typical of genus but number of teeth indeterminable due to orientation. Legs typical of genus.

Remarks.—This very unusual species is known only from the type locality.

Habitat.—Known only from sugar pine bark removed from a living tree.

Apocheiridium fergusonii, new species

Figure 2

Specimens examined.—*Type records.* Oregon: Harney Co.; 18 km SE of Riley (1300 m), bark of *Juniperus occidentalis* Hook., 15 May 1972 (E. M. Benedict), 1 male (holotype AMNH); Diamond Craters (1280 m), bark of *J. occidentalis*, 17 June 1973 (E. M. Benedict), 1 male (paratype EMB); Deschutes Co.; 19 km N of Bend, bark of *J. occidentalis*, 8 April 1937 (J. C. Chamberlin), 1 female, 1 nymph (paratypes JCC).

Etymology.—The specific name is a patronym in honor of Dr. Denzel Ferguson, Director of the Malheur Field Station, who has greatly encouraged my research efforts in southeastern Oregon.

Distribution.—Known only from eastern Oregon.

Diagnosis.—Based on adults only. Body length of male 1.21-1.33 mm, of female 1.38 mm; palpal femur length 0.33-0.35 mm; proximal third of femur (exclusive of pedicel) somewhat enlarged but bulging slightly *only* on lateral margin, medial margin relatively straight, femur length/breadth ratios 4.1-4.3; dorsum of chelal hand with numerous large granules intermixed with moderately sized ones.

Description.—Measurements in Table 1, morphometric ratios in Table 6. Carapace with generally stellate rugosities; holotypic chaetotaxy 4-15(97±). Coxal chaetotaxy 2-3-4:1 or

0.4:2.4:2.3 or 4:2-4. Abdominal terga with generally stellate rugosities; chaetotaxy of holotype 19:21:16:22:24:26:28:30:30:25:13?:mm; of sterna 6:(3-3):(0)2/8(0):(0)9(0); 13:15:19:21:23:18:6:mm. Chelicera typical of genus. Palp (Fig. 2) moderately slender except for moderate size enlargement of proximal third of femur; derm mostly coarsely granulate intermixed with moderately size fine granulations; finger with 10-12 teeth of typical generic facies. Legs of typical generic facies.

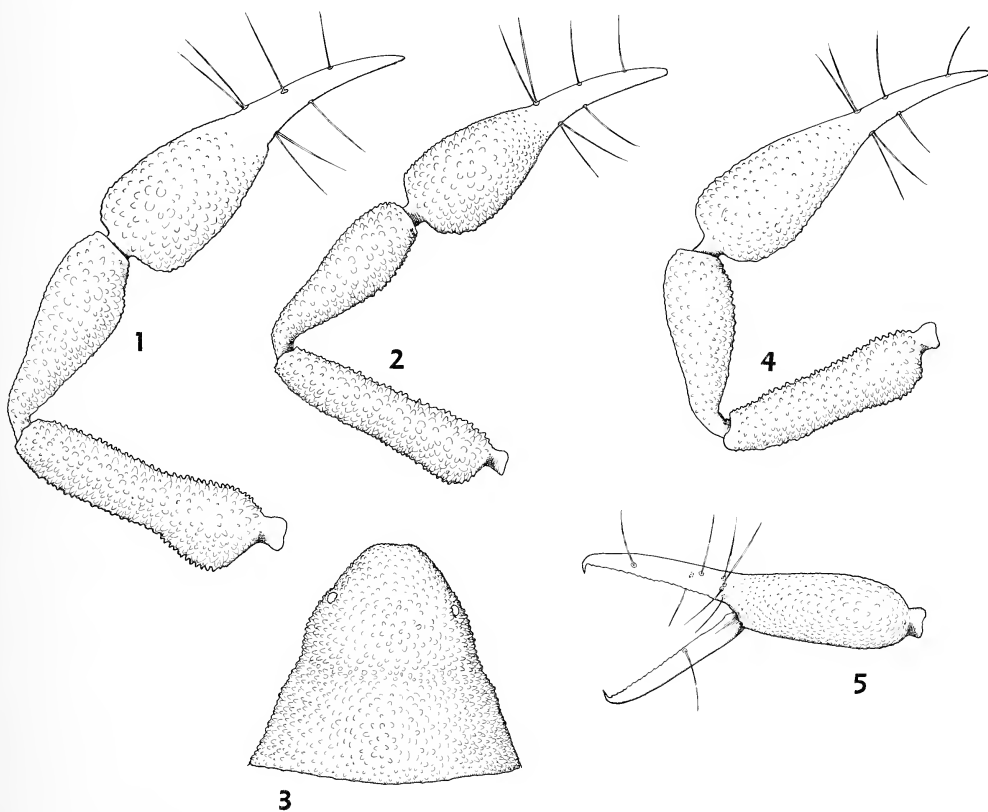
Remarks.—*Apocheiridium bulbifemorum* and *A. fergusonii* appear to be relatively similar in most characters except for the shape of the palpal femur. The medial margin of *A. fergusonii* is nearly straight and lacks a concavity above the exceedingly slight basal enlargement; in *A. bulbifemorum*, both margins are markedly swollen basally with a constriction just distal to the basal enlargement.

Habitat.—Known only from western juniper bark removed from a living tree.

Apocheiridium ferumoides Chamberlin

Apocheiridium ferumoides Chamberlin, 1924:34 (type species), 1931:238, 1932:139; Gering, 1956:49; Vestal, 1938:13.

Distribution.—Known from coastal areas between Morro Bay, California, and Astoria, Oregon. Gering (1956) listed it for the Great Salt Lake Desert in Utah, but its



Figs. 1-5.—New species of *Apocheiridium* from western North America: 1, *A. bulbifemorum*, dorsal aspect of pedipalp of holotype female; 2, *A. fergusonii*, dorsal aspect of pedipalp of holotype male; 3, *A. granochelum*, carapace of holotype female; 4, *A. granochelum*, dorsal aspect of pedipalp of holotype; 5, *A. granochelum*, lateral aspect of chela of holotype.

Table 2.—Measurements (in mm) of *Apocheiridium ferumoides* Chamberlin from the western United States (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable).

	12 ♂♂	8 ♀♀
Body L	1.35-1.46	1.48-1.77
Abdominal B	0.70-0.80	0.73-0.83
Carapace L	0.40-0.44	0.42-0.45
Ocular B	0.22-0.24	0.24-0.28
Posterior B	0.47-0.51	0.52-0.60
Eye Diameter	0.019-0.031	0.020-0.031
Chelicera L/B	0.08-0.10/0.04-0.06	0.08-0.10/0.05-0.07
Pedipalp		
Trochanter L/B	0.18-0.20/0.11-0.12	0.19-0.21/0.12-0.13
Femur L/B	0.32-0.39/0.08-0.10	0.36-0.39/0.09-0.11
Tibia L/B	0.27-0.31/0.10-0.11	0.30-0.33/0.10-0.11
Chela L/B	0.44-0.47/0.13-0.15	0.47-0.54/0.15-0.17
Hand L	0.21-0.24	0.23-0.24
Movable finger L	0.22-0.25	0.24-0.28
Leg I		
Entire femur L/D	0.18-0.20/0.06-0.08	0.19-0.21/0.06-0.07
Tibia L/D	0.17-0.19/0.04-0.05	0.19-0.20/0.04-0.06
Tarsus L/D	0.10-0.13/0.02-0.03	0.12-0.13/0.03-0.04
Leg IV		
Entire femur L/D	0.25-0.29/0.06-0.07	0.28-0.31/0.06-0.08
Tibia L/D	0.17-0.19/0.04-0.05	0.19-0.20/0.04-0.06
Tarsus L/D	0.14-0.17/0.02-0.04	0.15-0.17/0.03-0.04

presence there needs confirmation, since superficially similar species can easily be confused.

Diagnosis.—Based on adults only. Body length of male 1.35-1.46 mm, of female 1.48-1.77 mm; palpal femur length 0.32-0.39 mm; proximal third of femur (exclusive of pedicel) somewhat enlarged but bulging slightly only on lateral margin; medial margin relatively straight, femur length/breadth ratios 3.5-4.3; dorsum of chelal hand with a few coarse granules intermixed with numerous moderately sized ones.

Remarks.—Measurements in Table 2; morphometric ratios in Table 6. See Chamberlin (1931) for illustrations of various morphological parts (17 figures) of *A. ferumoides*. Chamberlin's (1924, 1932) description of the species is generally useful if considered in view of the characters provided herein for the genus and species. The new specimens, reported below, appear to be conspecific with the specimens described by Chamberlin, even though they exhibit a greater size range. Although *A. ferumoides* and *A. mormon* are about the same size, the palpal podomeres are much stouter in the former species than in the latter.

Habitat.—Chamberlin (1924, 1932) reported it from bark of eucalyptus, oak, cypress, pine and redwood trees; Vestal (1938) from the nests of woodrats; whereas, the new specimens, reported below, were collected from bark of Sitka spruce, Douglas fir and western red cedar trees.

Specimens examined.—California: Santa Clara Co.; Palo Alto, Stanford University Campus, bark of *Eucalyptus*, 17 January 1922 (J. C. Chamberlin), 3 males (holotype, 2 paratypes JCC), 3 females (allotype, 2 paratypes JCC); Stanford University campus, bark of *Eucalyptus*, 15 October 1922 (J. C. Chamberlin), 1 male, 1 female (paratypes JCC); San Mateo Co.; Atherton, bark of *Cupressus macrocarpa* Hartw. ex Gord., 23 October 1922 (J. C. Chamberlin), 4 females (JCC); Atherton, no data, 1 female (JCC); Alameda Co.; Berkeley, University of California campus, bark of *Eucalyptus*, 22 August 1921 (O. E. Essig), 1 male, 2 females (JCC); Berkeley, bark of *Eucalyptus*, 7 October 1951 (W.

C. Bentinck), 6 males, 2 females (ROS): San Luis Obispo Co.; Morro Bay, 16 April 1967 (P. Weygoldt), 1 male (WBM). Oregon: Clatsop Co.; Astoria, bark of *Picea sitchensis* (Bong.) Carr., 23 April 1936 (J. C. Chamberlin and K. W. Gray), 2 males, 2 females (JCC): Douglas-Lane Co. line; Coast highway, bark of *Pseudotsuga menziesii* (Mirb.) Franco, 26 April 1936 (J. C. Chamberlin), 1 male, 1 female (JCC): Lane Co.; near Glenada, 26 April 1937 (J. C. Chamberlin), 1 male (JCC): Lincoln Co.; 3 km N of Waldport, bark of *Thuja plicata* Donn, 14 March 1937 (J. C. Chamberlin and J. Schuh), 2 males, 2 females (JCC); 10 km E of Newport, bark of *Picea sitchensis*, 4-6 September 1946 (J. C. Chamberlin), 1 male, 1 female (JCC); 1 km NE of Elk City, bark of *P. sitchensis*, 20 December 1971 (E. M. Benedict), 1 male, 1 female (EMB): Tillamook Co.; 3 km E of Oretown, bark of *P. sitchensis*, 12 March 1975 (E. M. Benedict), 1 nymph (EMB).

Apocheiridium granochelum, new species
Figures 3-5

Specimens examined.—*Type records.* Oregon: Benton Co.; Corvallis, bark of *Quercus* sp., 3 September 1937 (J. Schuh), 1 female (holotype AMNH), 1 male (allotype AMNH), Corvallis, bark of *Quercus* sp., 9 March 1937 (J. Schuh), 1 female (paratype JCC): Columbia Co., Scappoose, bark of *Fraxinus latifolia* Benth., 19 February 1937 (K. W. Gray and J. Schuh), 2 males, 2 females (paratypes JCC).

Etymology.—The specific name refers to the granular nature of the chelal hand.

Distribution.—Known only from Benton and Columbia Counties, Oregon.

Diagnosis.—Based on adults only. Body length of male 0.89-1.09 mm, of female 0.94-1.22 mm; palpal femur length 0.27-0.29 mm; proximal third of femur (exclusive of pedicel) somewhat enlarged but not especially bulging on medial or lateral margins, femur length/breadth ratios 3.8-4.1; dorsum of chelal hand with a number of coarse granules intermixed with fine ones.

Description.—Measurements in Table 3, morphometric ratios in Table 7. Carapace (Fig. 3) with generally roundish rugosities; chaetotaxy 4-17(85±). Coxal chaetotaxy 2-2-5:2-2

Table 3.—Measurements (in mm) of *Apocheiridium granochelum*, new species from Oregon (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable).

	3 ♂♂	4 ♀♀
Body L	0.89-1.09	0.94-1.22
Abdominal B	0.54-0.57	0.59-0.64
Carapace L	0.33-0.35	0.34-0.36
Ocular B	0.18-0.20	0.19-0.20
Posterior B	0.36-0.40	0.38-0.42
Eye diameter	0.020-0.025	0.019-0.020
Chelicera L/B	?-0.07/0.04-?	?/?
Pedipalp		
Trochanter L/B	0.15-0.17/0.08-0.09	0.15-0.16/0.09-0.10
Femur L/B	0.27-0.28/0.07	0.27-0.29/0.06-0.07
Tibia L/B	0.23-0.24/0.07	0.22-0.23/0.07-0.08
Chela L/B	0.34-0.35/0.09-0.10	0.35-0.37/0.10-0.11
Hand L	0.16-?	0.18-0.19
Movable finger L	0.19-?	0.18-0.19
Leg I		
Entire femur L/D	0.14-0.14/0.05-0.06	0.15-0.16/0.05-0.06
Tibia L/D	0.10/0.03-0.04	0.10-0.11/0.04-0.05
Tarsus L/D	0.10/0.02-0.03	0.09-0.10/0.02-0.03
Leg IV		
Entire femur L/D	0.20-0.21/0.05-0.06	0.20-0.21/0.05-0.06
Tibia L/D	0.14-0.15/0.03-0.04	0.14-0.15/0.03-0.04
Tarsus L/D	0.11-0.12/0.02-0.03	0.11-0.13/0.02-0.03

or 3:2-3:2-3:2-5. Abdominal terga with generally roundish rugosities; chaetotaxy of holotype 22:22:20:22:28:31:32:30:29:26:12: mm, of sterna 13:(0)9(0):(0)13(0);16:14?:22:22:21:15:8: mm. Chelicera typical of genus. Palp (Fig. 4) relatively slender except for very slight enlargement of proximal third of femur, both margins slightly concave distad of enlargement; derm coarsely granulate intermixed with fine granules; fingers each with 10-12 teeth of typical generic facies. Legs of typical generic facies.

Remarks.—Although *A. inexpectum* and *A. granocheulum* resemble each other superficially and are about the same size, the derm of the chelal hand in *A. granocheulum* is markedly granular, the hand is more swollen interiorly, and the femur is broader basally than in *A. inexpectum*. Also, the two species appear to be isolated geographically, since *A. inexpectum* is known to occur from southern California to Baja California, while *A. granocheulum* has been collected only from western Oregon.

Habitat.—Known only from Oregon ash and oak bark removed from living trees.

Apocheiridium inexpectum Chamberlin

Apocheiridium ferumoides Chamberlin, 1924:34 (in part, misidentification).

Apocheiridium inexpectum Chamberlin, 1932:138; Beier, 1932:11.

Distribution.—Known only from Monterey, San Bernardino, Riverside and Imperial Counties of southern California (United States), and Baja California (Mexico).

Diagnosis.—Based on adults only. Body length of male 1.03-1.16 mm, of female 1.08-1.24 mm; palpal femur length 0.28-0.31 mm; proximal third of femur (exclusive of pedicel) somewhat enlarged but bulging slightly only on lateral margin; medial margin relatively straight, femur length/breadth ratios 4.3-4.8; dorsum of chelal hand very finely granulate to nearly smooth, coarse granules nearly absent.

Table 4.—Measurements (in mm) of *Apocheiridium inexpectum* Chamberlin from California (Abbreviations: B=breadth; D=depth; L=length).

	5 ♂♂	8 ♀♀
Body L	1.03-1.16	1.08-1.24
Abdominal B	0.57-0.61	0.59-0.69
Carapace L	0.33-0.39	0.35-0.38
Ocular B	0.18-0.20	0.19-0.21
Posterior B	0.38-0.41	0.40-0.45
Eye Diameter	0.024-0.025	0.022-0.025
Chelicera L/B	0.07-0.08/0.03-0.04	0.07-0.08/0.03-0.04
Pedipalp		
Trochanter L/B	0.13-0.14/0.08-0.09	0.14-0.16/0.08-0.09
Femur L/B	0.28-0.30/0.06-0.07	0.29-0.31/0.06-0.07
Tibia L/B	0.24-0.26/0.07-0.08	0.25-0.27/0.07-0.08
Chela L/B	0.35-0.37/0.09-0.10	0.35-0.38/0.09-0.11
Hand L	0.17	0.14-0.19
Movable finger L	0.19	0.19-0.20
Leg I		
Entire femur L/D	0.15-0.16/0.05-0.06	0.17-0.18/0.05-0.06
Tibia L/D	0.10-0.11/0.03-0.04	0.10-0.11/0.03-0.04
Tarsus L/D	0.10-0.11/0.02-0.03	0.10-0.11/0.02-0.03
Leg IV		
Entire femur L/D	0.20-0.21/0.05-0.06	0.21-0.23/0.06-0.07
Tibia L/D	0.13-0.14/0.03-0.04	0.16-0.17/0.03-0.04
Tarsus L/D	0.12-0.13/0.02-0.03	0.12-0.13/0.02-0.03

Remarks.—Measurements in Table 4; morphometric ratios in Table 7. Chamberlin (1932:138, 140) and Beier (1932:11, 13) both give the same inconsistent ratios for femur length/breadth as follows: “3.8-3.9” (in description) and “4.3-4.4” (in key). The latter range is consistent with my measurements of 15 specimens (Table 7). Unfortunately, most of the specimens were KOH treated and mounted nearly whole so that measurements and, in turn, ratios are rough approximations for some podomeres.

Habitat.—known from eucalyptus, mesquite and sycamore bark.

Specimens examined.—California: Riverside Co.; Beaumont, bark of *Eucalyptus*, 11 November 1925 (J. C. Chamberlin), 3 males (holotype, 2 paratypes JCC), 2 females (allotype, 1 paratype JCC); Box Springs Grade near Riverside, bark of sycamore, 26 November 1925 (J. C. Chamberlin), 2 males, 6 females (paratypes JCC); Imperial Co., Midway Well, bark, 27 January 1965 (R. O. Schuster), 3 males, 2 females (ROS); Monterey Co.; Los Baños above Gonzales, sycamore bark, 28 March 1935 (J. C. Chamberlin and G. York), 2 females (JCC); San Bernadino Co., 2.5 km N of Cajon Pass, 12 June 1960 (H. L. McKenzie), 1 male (ROS).

Apocheiridium mormon Chamberlin

Apocheiridium mormon Chamberlin, 1924:34, 1932:138.

Distribution.—Known only from Bear Lake County, Idaho, and Benton County, Oregon.

Diagnosis.—Based on adults only. Body length of male 1.30-1.35 mm, of female 1.38-1.40 mm; palpal femur length of male 0.33-0.39 mm, of female 0.40-0.44 mm; proximal third of femur (exclusive of pedicel) only slightly enlarged, both margins relatively straight, femur length/breadth ratios 4.6-4.9; dorsum of chelal hand with a number of coarse granules intermixed with moderately sized ones.

Remarks.—Measurements in Table 5; morphometric ratios in Table 7. This species is unique among western North American species for its slender pedipalps. Both margins of

Table 5.—Measurements (in mm) of *Apocheiridium mormon* Chamberlin from Idaho and Oregon (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable).

	3 ♂♂	3 ♀♀
Body L	1.30-1.35	1.38-1.40
Abdominal B	0.64-0.71	0.77-0.81
Carapace L	0.38-0.42	0.45-0.46
Ocular B	0.21-0.25	0.23-0.24
Posterior B	0.45-0.47	?
Eye diameter	0.022-0.025	0.025-0.026
Chelicera L/B	0.08-0.09/0.04-0.05	0.09-0.10/0.04-0.05
Pedipalp		
Trochanter L/B	0.17-0.19/0.08-0.10	0.20-0.21/0.12-0.13
Femur L/B	0.33-0.39/0.07-0.08	0.40-0.44/0.08-0.09
Tibia L/B	0.28-0.32/0.07-0.08	0.34-0.35/0.08-0.09
Chela L/B	0.43-0.49/0.11-0.12	0.48-0.53/0.13-0.14
Hand L	0.22-0.23	0.23-0.25
Movable finger L	0.24-0.25	0.26-0.29
Leg I		
Entire femur L/D	0.18-0.20/0.05-0.06	0.20-0.22/0.06-0.07
Tibia L/D	0.11-0.12/0.03-0.04	0.13-0.14/0.04-0.05
Tarsus L/D	0.12-0.13/0.02-0.03	0.12-0.14/0.03-0.04
Leg IV		
Entire femur L/D	0.25-0.27/0.05-0.06	0.29-0.31/0.06-0.07
Tibia L/D	0.17-0.18/0.04-0.05	0.20-0.21/0.04-0.05
Tarsus L/D	0.13-0.15/0.03-0.04	0.16-0.17/0.03-0.04

Table 6. Morphometric ratios of three species of *Apocheiridium* Chamberlin from western North American (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable).

	<i>A. bulbi- femorum</i>	<i>A. fergusoni</i>		<i>A. ferumoides</i>	
	1 ♀	2 ♂♂	1♀	12 ♂♂	8 ♀♀
Pedipalp					
Femur L/B	3.9	4.1-4.3	4.2	3.5-4.1	3.5-4.3
Tibia L/B	3.0	3.1-3.2	3.1	2.6-3.0	2.7-3.0
Chela L/B	3.2	3.2-3.3	3.0	3.1-3.5	3.0-3.4
Movable finger L/					
Hand L	1.1	1.1-1.2	?	1.0-1.2	1.0-1.2
Hand L/B	1.7	1.4-1.5	?	1.5-1.7	1.5-1.7
Chela L/Tibia B	4.5	4.5-4.6	4.3	4.2-4.7	4.3-4.9
Leg I					
Entire femur L/D	?	2.8-2.9	?	2.4-3.0	2.6-3.2
Tibia L/D	?	2.6	?	2.3-2.8	2.4-2.6
Tarsus L/D	?	2.2-2.3	?	3.3-4.6	3.4-3.9
Leg IV					
Entire femur L/D	?	4.1-4.3	?	3.5-4.1	3.8-4.1
Tibia L/D	?	3.7-3.8	?	3.5-4.3	3.6-3.8
Tarsus L/D	?	3.7-3.8	?	3.4-4.5	4.1-4.5

Table 7.—Morphometric ratios of three species of *Apocheiridium* Chamberlin from western North America (Abbreviations: B=breadth; D=depth; L=length; ?=indeterminable).

	<i>A. granochelum</i>		<i>A. inexpectum</i>		<i>A. mormon</i>	
	3 ♂♂	4 ♀♀	5 ♂♂	8 ♀♀	3 ♂♂	3 ♀♀
Pedipalp						
Femur L/B	3.8-4.0	3.8-4.1	4.3-4.6	4.4-4.8	4.6-4.9	4.6-4.8
Tibia L/B	3.0-3.3	2.9-3.1	3.3-3.5	3.1-3.6	3.6-3.8	3.7-3.8
Chela L/B	3.3-3.6	?	3.5-3.7	3.3-3.6	4.1-4.3	3.6-3.9
Movable finger L/						
Hand L	1.2-?	1.0-?	1.1-1.2	1.1-1.2	1.1-1.2	1.1-1.2
Hand L/B	1.6-?	1.7	1.7-1.8	1.6-1.8	1.8-1.9	1.7-1.9
Chela L/Tibia B	4.6-4.8	4.4-4.8	4.7-4.9	4.7-5.1	5.5-6.0	5.4-5.7
Leg I						
Entire femur L/D	2.8	?	?-2.9	2.9-3.0	2.9-3.3	3.1-3.2
Tibia L/D	2.5-2.9	2.2-2.5	2.6-2.7	2.7-2.8	3.0-3.1	2.9-3.1
Tarsus L/D	4.0	3.5-3.8	?-4.2	3.5-?	4.0-4.2	3.9-4.0
Leg IV						
Entire femur L/D	3.8	3.6-3.8	3.7-4.2	3.4-3.6	4.0-4.3	4.3-4.6
Entire femur L/D	3.8-4.2	3.8-4.2	3.8-4.0	4.1-4.4	4.1-4.4	4.9-5.0
Tarsus L/D	3.8-4.4	4.2-4.3	?	4.3-4.6	4.5-4.7	4.8-5.1

the femur are relatively straight with a very shallow concavity only on the lateral margin (see Chamberlin 1924, fig. Z). Chamberlin described *A. mormon* from a single male specimen from Idaho and, until now, no new specimens have been reported for the species. The Oregon specimens agree in detail with the holotype but are slightly larger in some podomeres. The listings of this species by Chamberlin (1924, 1932), Beier (1932) and Hoff (1958) for Utah have not been supported by collection records or specimens. Therefore, while *A. mormon* likely occurs in Utah, its presence there needs verification.

Habitat.—Known from bark of a mountain mahogany, an oak and an old fence post.

Specimens examined.—Idaho: Bear Lake Co.; Fish Haven, bark of *Cercocarpus*, 8 September 1921 (J. C. Chamberlin), 1 male (holotype JCC). Oregon: Benton Co.; Granger, bark of fence post, 16 February 1938 (J. C. Chamberlin and K. W. Gray), 2 males, 2 females (JCC); Corvallis, bark of *Quercus* sp., 3 March 1937 (J. Schuh), 1 female (JCC).

ACKNOWLEDGEMENTS

I am deeply indebted to David R. Malcolm of Pacific University for allowing me access to the specimens and papers of the late J. C. Chamberlin (JCC); to William B. Muchmore (WBM) of the University of Rochester and to Robert O. Schuster (ROS) of the University of California at Davis for loaning me specimens; to Wanetah D. Bell for translating Vitali-di Castri's papers; and to Susan Lindstedt for preparing the figures. Holotypes and allotypes of new species are deposited in American Museum of Natural History (AMNH); my specimens (EMB) in the combined Benedict-Chamberlin-Malcolm Collection.

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BURROWING BIOLOGY OF THE SCORPION *CHELOCTONUS JONESII* POCK (ARACHNIDA: SCORPIONIDA: SCORPIONIDAE)

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ABSTRACT

The burrowing biology of *Cheloctonus jonesii* Pocock from southern Africa is described. Pedipalpal burrowing is dealt with for the first time, and related to aspects of the ecology of this scorpion.

INTRODUCTION

Little has been reported on pedipalpal burrowing among scorpions and the subject remains controversial. Pocock (1896) suggested that members of the north African genus *Scorpio* L. and the southern African genus *Opisthophthalmus* C. L. Koch excavate their burrows with their pedipalps. Since then, Newlands (1972) has ascertained that *Opisthophthalmus* spp. do not burrow in this fashion, but use their chelicerae to loosen the soil which is then gathered by the first pair of legs. Cloudsley-Thompson (1955) suggested that the pedipalps of *Scorpio maurus* L. are especially adapted for excavating burrows, but Newlands (1969) believes that the enlarged chelae in this species provide a protective shield while the scorpion is inside the burrow.

The burrowing biology of *Cheloctonus jonesii* Pocock is described here. The scorpion *C. jonesii* occurs in Zimbabwe (Rhodesia), Swaziland, Mozambique and South Africa, and within South Africa is found mostly in the northeastern and eastern Transvaal and in Natal. It is very abundant in Zululand (Natal) where densities of about 2 burrows per 3m² have been found (Newlands, pers. comm.). *C. jonesii* appears to be restricted to areas of high rainfall (about 801-1250mm/year) in conjunction with soils of high clay content. Newlands (1972) associates it with pelitic soils, such as black turf. This species is more abundant on plains than in valleys, preferring coarsely and sparsely grassed areas, where it constructs its burrows in open veld at the base of (or among) grass tufts or occasionally under rocks.

MATERIALS AND METHODS

Field studies were carried out at Newington (eastern Transvaal), near Skukuza Kruger National Park), and at Pongola (in Zululand) in Natal Province, South Africa. Fifty

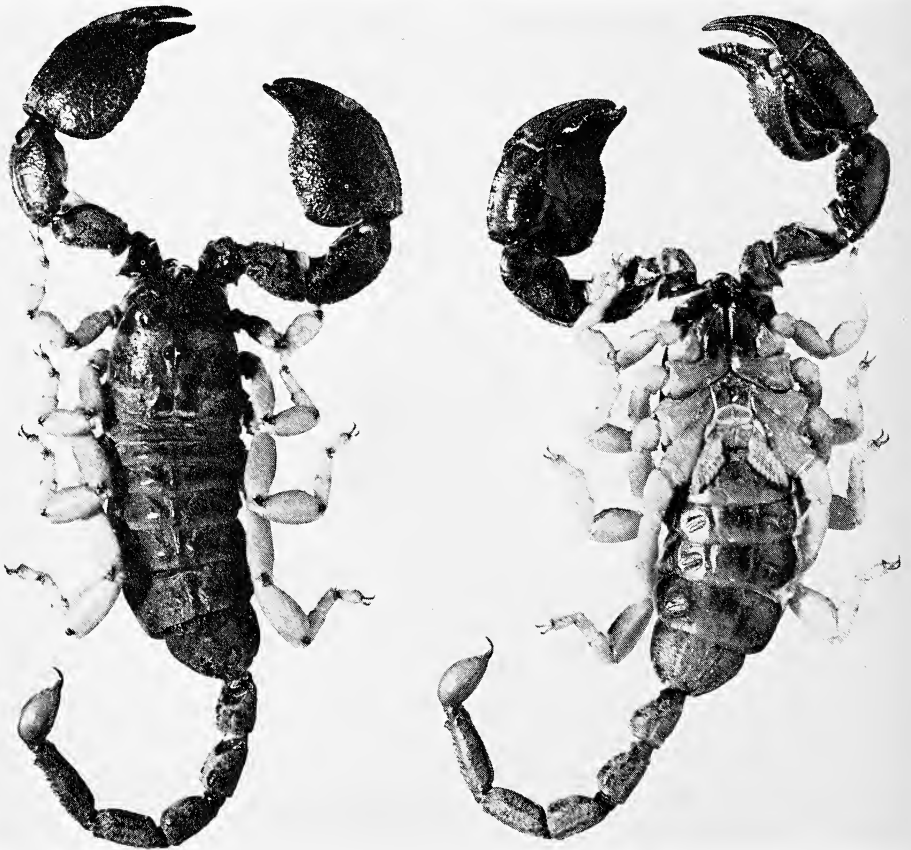
burrows were carefully excavated, and occasionally plaster casts were made to obtain data on burrow structure.

Laboratory studies were performed in 40 liter terraria two-thirds filled with soil from the original habitat, and prepared to approximate natural conditions. Mature scorpions did not construct burrows in captivity, and observations were made on juvenile specimens. These scorpions did not excavate burrows during daylight hours, and all observations were made at night with the aid of visible red light.

OBSERVATIONS

Cheloctonus jonesii has the morphological traits commonly associated with fossorial habits in hard-packed soils. Among these are: heavy body; stout pedipalps with rounded chelae and broad, short fingers; relatively short metasoma (about 50% of total body length); and relatively short, stout legs with the tarsi armed ventrally with strong spines (Figs. 1 and 2).

Description of the burrow.—The burrow is generally found at the base of a tuft of coarse grass, or among two or three tufts. In the former case the tumulus is usually seen on one side of the burrow entrance only, while in the latter the tumulus is spread out



Figs. 1-2.—External morphology of *Cheloctonus jonesii* Pocock: 1, dorsal view; 2, ventral view (scale in mm).

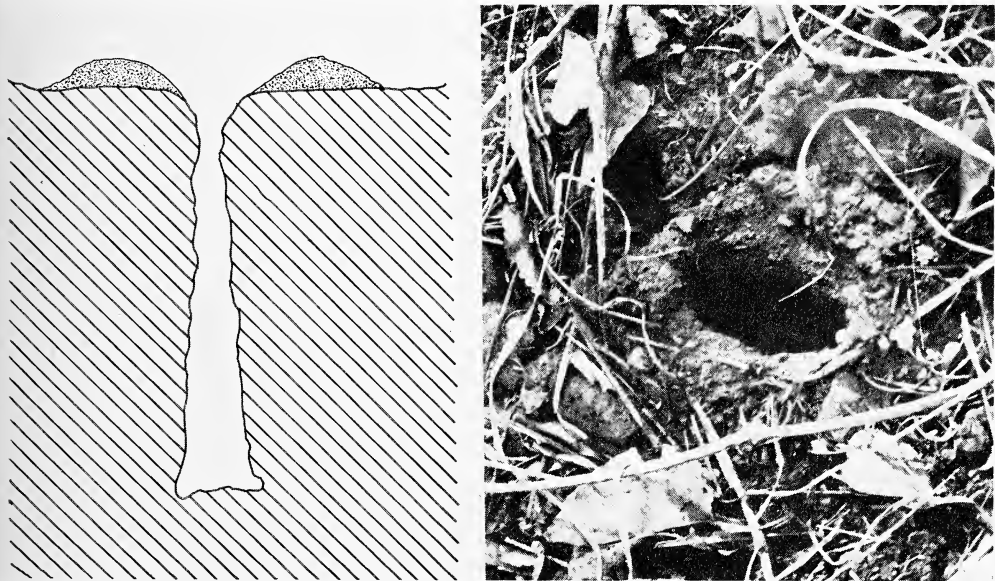
radially from the burrow entrance. The burrow is a simple tunnel with an oblong entrance (Figs. 3 and 4), penetrating the ground at about 70°-90° from the horizontal, and its diameter increases about one-third of the way down to about twice its entrance width. Burrow measurements taken in the field (Table 1) show little variability with the exception of depth as burrows of very young individuals are unusually shallow. Side tunnels are occasionally constructed, and in the Pongola region many of the excavated burrows had very short side tunnels (length less than about 3 cm). Exuviae, prey remains, and vegetal detritus were found in the short horizontal branches constructed from the terminal part of the main burrow. No second entrances to burrows were found.

Table 1.—Average measurements (in centimeters) of 42 burrows inhabited by *Cheloctonus jonesii* Pocock at Newington, Eastern Transvaal, South Africa (range in parenthesis).

	Males (n=10)	Females (n=17)	Immatures (n=15)
Entrance: width	2.8(1.5-3.5)	2.8(2.5-3.5)	2.2(1.5-3.3)
height	1.1(0.8-1.5)	1.3(0.8-2.5)	0.9(0.4-2.0)
Total depth:	18.5(14.0-22.0)	18.3(13.0-24.0)	15.6(4.0-22.0)

Digging behaviour.—Excavating the burrow is a lengthy process taking the scorpion two to three nights. Burrow construction in *C. jonesii* can be divided into three stages: (a) search for a suitable site, (b) soil loosening, and (c) soil transport.

Search. In apparent random behaviour the scorpion examines a large area before digging starts. The pectinal teeth are dragged continuously over the substrate, tending to support Carthy's (1968) suggestion that the sensory pegs on the teeth are mechano-



Figs. 3-4.—The burrow of *Cheloctonus jonesii* Pocock: 3, diagrammatic section of a burrow (about 20 cm deep); 4, typical burrow entrance (about 3 cm wide).

receptors involved in substrate selection. The pedipalps are also used occasionally by the scorpion to probe depressions and similar topographical features.

Soil loosening. The scorpion initiates this stage by extending and lifting the pedipalps. The trunk is arched dorsally, and is supported by the legs and the cauda. The metasoma is arched ventrally, and the ventral surfaces of segments 2 and 3 rest on the substrate. The pedipalps are then flexed (though not as strongly as in the resting position), and the chelae with slightly opened fingers are forced into the ground. The soil is loosened by forcefully wedging the chelal fingers almost vertically into the ground, and then flexing the chela. The convex external surfaces of the chelae function as fulcrum after the initial 0.5cm of burrowing. Thus, the pedipalps are used much like "spades", and I consider the breadth, and relative shortness of the chelal fingers in *C. jonesii* to be an adaptation for excavation. Initially alternate pedipalps are used, but when burrowing has developed they are used simultaneously (Fig. 5).

Soil transport. Loose soil must be transported out of the vertical burrow shaft and away from its entrance. As in soil loosening, the pedipalps are the only appendages used for this purpose. One pedipalp is extended and then flexed, with the chela scooping loose soil and trapping it against the coxae, trochanters, femora and chelicerae. Similarly, the other pedipalp chela scoops more soil and traps it against the external face of the first chela (Fig. 6). Scooping and trapping of soil are done in one motion. Clods and small stones are taken between the chelal fingers, smaller ones by one chela and larger ones by both. Grass rootlets are grasped by both chelae and pulled loose, with an occasional thrust of the metasoma to snap the rootlet. The inner surfaces of the chelae are extensively granulated, providing friction against the slipping of collected soil.

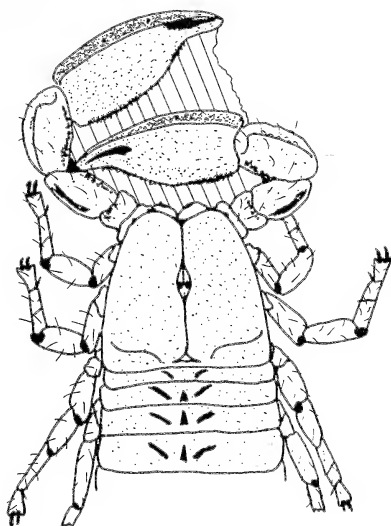
The "loaded" scorpion (with soil, a stone or a rootlet) backs up and out of the burrow. During this maneuver the first two pairs of legs push upwards while the last two pairs pull. During the climb the metasoma is flexed and the ventral surface of segment 5 (and sometimes 4) is pressed against the opposite burrow wall, acting both as a brace against slipping down and as a lever for moving up. The ventral keels on segment 5 are formed of posteriorly directed denticles; these denticles apparently function to facilitate vertical soil transport and not for tail-scraping as in many other fossorial scorpions. The rows of ventrolateral setae on caudal segment 5 found in most burrowing scorpionids are absent in *C. jonesii*. Upon reaching the burrow entrance the scorpion turns around and drops the load a few centimeters away. When the soil heaps up it is flattened and levelled by pushing with alternating pedipalps. Any soil particles caught between the chelal fingers are removed by the opposite chela after soil deposition.

Maintenance of the burrow consists of removing prey remains and unwanted soil, and is accomplished in a similar fashion to that described for soil transport. Examination of burrow tumuli and walls has shown that maintenance operations occur especially after rains (Fig. 4).

Interspecific interactions.—Much of the life of *C. jonesii* is centered in and around the burrow, and interspecific interactions are often conspicuous in this respect. My observations pertain to prey, predators and commensals.

Prey. The vertical burrow shaft of *C. jonesii* functions as a "pit-fall" trap for unwary prey. The remains recovered from excavated burrows consisted mainly of dung beetles and small tenebrionids.

Laboratory observations on scorpions feeding outside the burrow revealed that *C. jonesii* usually stings its prey. Stinging is done sideways rather than "overhead" (an action



Figs. 5-6.—Digging behaviour in *Cheloctonus jonesii* Pocock: 5, method of soil loosening; 6, method of soil transport.

that might be impeded inside the burrow). Prey are stung even where it is apparently unnecessary to subdue them.

Predators. Animals known to prey on *C. jonesii* are centipedes (*Scolopendra* sp.) and Lesser Red Musk Shrews (*Crocidura hirta* Peters) (collected in the field and fed in the laboratory). Studies by A. C. Kemp have shown that the hornbills *Tockus erythrorhynchus* (Temminck), *T. flavoristris* (Rüppell) and *T. nasutus* (Linnaeus) are predators of *C. jonesii*. The two former species are ground foragers and caught 95% of the total number of scorpions presented, while the latter is mainly arboreal and not an important predator (Kemp, pers. comm.). A large amount of *C. jonesii* remains were found among the tumuli of Bushveld gerbil (*Tatera leucogaster* Peters) burrows at Newington. In addition to this, chitinous remains were also found in gerbil faeces. These two observations suggest the Bushveld gerbil as a certain predator of *C. jonesii*. A well preserved whole scorpion was found in the faeces of the Cape porcupine, *Hystrix africae-australis* Peters (identified by I. L. Rautenbach), but since porcupines are vegetarians it is likely that the scorpion was ingested accidentally while on the surface (Rautenbach, pers. comm.).

The borrow of *C. jonesii* provides excellent protection from hornbills, shrews and gerbils as the entrance is too narrow to prevent access to the burrow. Centipedes are able to enter but probably stand little chance of overcoming the inhabitant unless it is young.

The narrow entrance and upper third of the burrow act to hinder the entrance of predators, while the wider lower two-thirds of the burrow provide ample maneuvering space for the scorpion. The massive chelae of *C. jonesii* serve not only to block access into the burrow for potential intruders, but also shield the front end of the scorpion from direct attack, and make it very difficult for potential predators to get a hold of the scorpion and pull it out of the burrow. If a potential predator succeeds in securing a grip of the pedipalp chela, the scorpion uses the legs to prevent itself from being dislodged, and could also use the metasoma to brace itself against the opposing burrow wall in a manner similar to that described for soil transport activities. Thus, most of the scorpions preyed upon are presumably taken outside the burrow (during maintenance operations or other surface activities).

Commensals. Crickets and terrestrial isopods were excavated from the terminal region of *C. jonesii* burrows. The terrestrial isopods presumably fell into the vertical burrow shafts and were unable to climb out, their distasteful and noxious properties preventing the scorpion from preying on them. The crickets might have wandered in or fallen in accidentally. Their means of escaping predation are not clear and permanent escape is probably rare. Lycosid spiders (*Lycosa* sp.) were found inhabiting the entrance and upper part in the majority of *C. jonesii* burrows at Newington and to a lesser extent at Pongola. These spiders were seen to leave the burrow, mainly during the night and occasionally during the day, presumably to hunt. Therefore they might not be actively competing for prey with the scorpion. If threatened, the spider retreats rapidly into the burrow, but rarely, if ever, ventures further than two-thirds of the way into the burrow. If coaxed with a blade of grass to penetrate deeper, they usually flee up and out. On one occasion, in the field, a spider fell into the terminal chamber and was seized by the scorpion. Apparent benefits to spiders occupying the upper part of *C. jonesii* burrows are effective protection against outside predators and dessication, and the burrows' role as a trap for prey.

DISCUSSION

Cheloctonus jonesii is the first confirmed pedipalpal burrower among fossorial scorpions. Most previously studied fossorial scorpions have burrows that are moderately inclined to nearly horizontal (Newlands 1969), and rely on their chelicerae, legs, and metasoma to loosen and transport soil from their burrows (Newlands 1972). Vertical burrows have been previously reported for the North American scorpion *Diplocentrus peloncillensis* Francke (Francke 1975), but nothing is known of the digging behaviour of this species. Morphologically, however, *D. peloncillensis* seems to be better adapted to dig with its legs since the last segments bear a pair of longitudinal rows of strong spines ventrally, and the pedipalp chelae are not as large and robust as in *C. jonesii*. An interesting ecological difference between these two species is that *D. peloncillensis* digs its vertical burrows under rocks, while *C. jonesii* does it in the open near or against tufts of coarse grass.

As mentioned earlier, the exposed burrow entrance of *C. jonesii* is valuable for prey capture, but the threat of flooding during rains could be serious. The evidence of burrow maintenance operations shortly after rains is an indication that flooding and subsequent deposition of soil in the burrows are not uncommon. Since *C. jonesii* occurs in areas of high rainfall it is possible that the vertical burrow and pedipalpal digging behaviour have

evolved to cope with the main problems of flooding and deposition. Such flooding and deposition near the entrance of an inclined burrow could easily trap the scorpion and lead to suffocation, while in a flooded vertical burrow, material carried in by flooding would slide down the sides and raise the floor of the tunnel. Furthermore fossorial scorpions that rely on their chelicerae, legs, and metasoma to excavate probably do so poorly in mud. If so, they could not dig their way out of a collapsed flooded burrow efficiently and if they survived, maintenance operations or construction of a new burrow could not be performed for some time, exposing the scorpion to the elements and predators. *C. jonesii* on the other hand, being a pedipalpal burrower and occupying a vertical burrow could escape the perils mentioned above. It must be recognized, however, that other non-pedipalpal burrowers living in slanted burrows, for example, *Opisthophthalmus glabrifrons* Peters, can be found in the same areas as *C. jonesii*.

ACKNOWLEDGEMENTS

I wish to express my most sincere thanks to Dr. O. F. Francke for his encouragement and most valuable criticism of this paper. In addition Mr. Frederick W. Wagner assisted in reviewing the manuscript. Mr. G. Newlands gave considerable and much valued advice as did Dr. J. S. Harington. I wish also to thank Mr. Newlands for figures 1 and 2. The kind co-operation of Dr. R. F. Lawrence, Mr. I. L. Rautenbach, Dr. A. C. Kemp and Dr. J. G. E. Lewis is acknowledged. Mrs. D. M. Fitzgerald and Mrs. S. Rule are thanked for all typing.

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The following special directions apply to authors of taxonomic papers:

(a). Do not use abbreviations to indicate that a new name or a new combination is being proposed in a primary heading (e. g., *A-us x-us*, new species, rather than *A-us x-us*, n. sp. or comparable abbreviations).

(b). Keys must be typed following the third example given in the *CBE Style Manual* (3rd ed., p. 66), which is as follows:

1. Use Arabic numerals to designate the leading entry of a couplet 2
Do not designate the second entry of a couplet, either by means of numbers, letters, or other marks 3
2. Type numbers flush to left margin, and start entry on third space. The second, and subsequent, lines of one entry must be indented five spaces STOP

(c). Synonymies must follow the abbreviated style shown below:

A-us x-us Jones 1930:3, 1935:9; Russell 1945:453; Smith 1954a:16, 1954b:678; Cooper and Lim 1955:18 (in part).

A-us y-us Bates 1932:18, fig. 4. NEW SYNONYMY.

A-us z-us: Miranda 1948:98 (misidentification); Harris 1951:3 (in part ?). (*nec A-us z-us* Zimmer

(d). Lists of specimens examined of a given taxon must be the last item typed in the treatment of that taxon as they will be set in smaller type. Adhere to the following style for listing specimens examined: Country: state or comparable political subdivision; county or district, detailed locality (elevation), 14 July 1945 (collector), 2 males, 5 females (acronym of institution where specimens are deposited), next detailed locality within that county, and so forth; next county in the same state; and so forth: next state in the same country; and so forth. Next country: and so forth. Punctuation rules are very simple. Use a period to separate countries, colon to separate states, semi-colon to separate counties, and commas to separate specific localities.

Acknowledgments.—Avoid overlooking persons who have in some substantial way assisted with the work. Authors of taxonomic papers should spell out the name, and indicate parenthetically the acronym, of institutions where specimens studied are deposited.

Literature cited.—Include only those publications to which reference is made in the text. Adhere to the *CBE Style Manual* or refer to a previous issue of The Journal of Arachnology for style. Do not abbreviate place names in journal citations. Repeat name(s) of author(s) in case of multiple entries.

Figure legends.—Provide one legend for each illustration to be reproduced singly, or for each “plate” consisting of several illustrations. Adhere to the following style:

Figs. 1-4.—*A-us x-us*, male from Timbaktu: 1, left leg; 2, right chelicera; 3, dorsal aspect of genitalia; 4, ventral aspect of abdomen.

Type all figure legends consecutively on same page(s), using double space within each legend and leaving 4 spaces between legends. Keep in mind that 85 characters and spaces represent one printed line; for each line subtract 4 mm from the maximum length permissible on full-page illustrations.

Abstract.—Abstracts should be a summary of the basic findings, and should not exceed 2 to 3 percent of the text in length. Papers in a language other than English must be accompanied by an English abstract as well as an abstract in the language of the text.

Footnotes.—Footnotes will be permitted on page 1 when it is appropriate to acknowledge grant support and to indicate change of address, etc. No footnotes will be permitted on any other page. Type footnotes on a page by themselves.

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Tables with legends.—Prepare all tables precisely as they are to be typeset. Construct tables as simply as possible. Include legend at the top of each. Make marginal notations in the text which clearly indicate the appropriate point of insertion of each table. Note that in these instructions “graphs” are regarded as “figures,” not “tables.”

The size of the printed page imposes a limit on the size of tables that can be accepted. On a normal, upright table these limits are 85 characters and spaces per line and 56 lines long, including legend. Tables printed sideways on a page can be up to 137 characters and spaces per line and 36 lines long, including legend. Sideways tables are difficult to typeset and present problems during paste-up; therefore, they will be accepted in exceptional cases only, as most tables that are “too wide” can usually be re-arranged to fit into the more desirable, upright position. Any table that exceeds the dimensions given above will not be accepted for publication. Tables must be typed double spaced throughout, and the legend must be in the following style:

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Printed by the Speleo Press, Austin, Texas

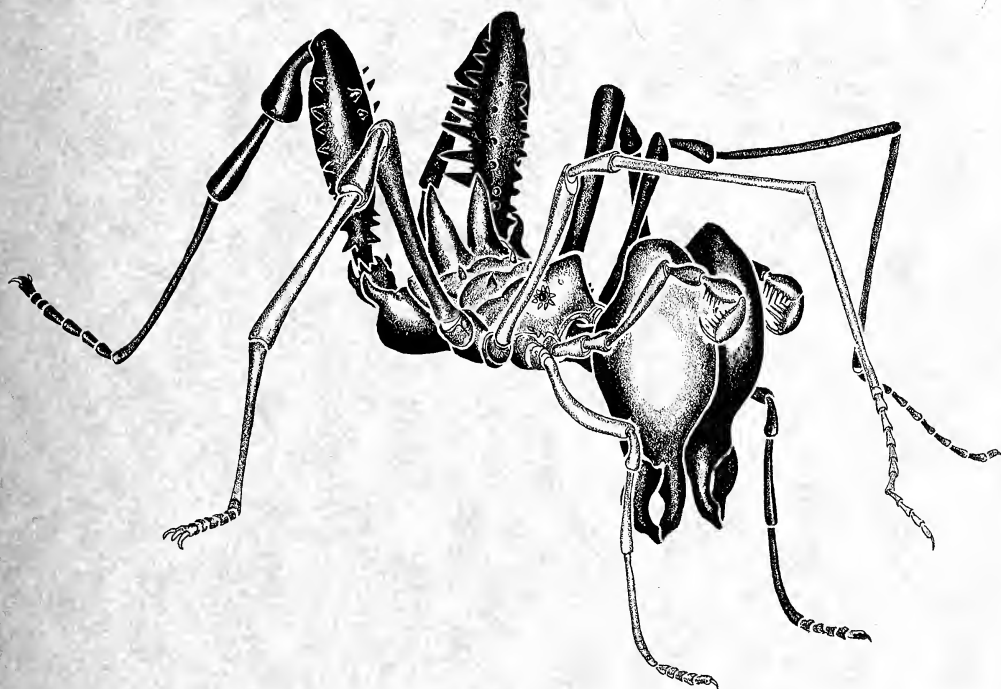
Posted at Warrensburg, Missouri, U.S.A., September 1978



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The Journal of ARACHNOLOGY

OFFICIAL ORGAN OF THE AMERICAN ARACHNOLOGICAL SOCIETY



VOLUME 6

WINTER 1978

NUMBER 1

1-30

THE JOURNAL OF ARACHNOLOGY

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LIFE HISTORY OF *PHIDIPPUS JOHNSONI* (ARANEAE, SALTICIDAE)

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ABSTRACT

In the laboratory, *P. johnsoni* oviposit successive batches of eggs with a trend toward a decrease in both number of eggs and proportion of eggs that hatch in later batches. Approximately one month elapses between copulation and the first oviposition, and another month elapses between each successive oviposition. Eggs hatch three weeks after oviposition, and spiderlings disperse from the maternal nest after another three weeks. Males mature earlier, pass through fewer molts, reach smaller adult size and have lesser adult longevity than females. There is considerable intrasexual variability in adult size, maturation time, and number of instars before reaching maturity. Males mature in 5 to 7 molts; females, 6 to 8. Instar duration and variability in instar duration is greater in later than in earlier instars. Morphometric data from the laboratory were employed for estimating the number of molts that spiders undergo in the Coastal Range of California. Spiders in nature matured later in the year and probably passed through more molts before reaching maturity (6 to 8 for males; 7 to 9 for females) than was the case for laboratory-reared spiders. Phenology and density were investigated in six populations: two from the Coastal Range of California, two from Beach habitats (sea level, next to the ocean) in California, and two from Alpine habitats (Sierra Nevada, California; Rocky Mountains, Wyoming). Densities were comparable in all populations except for one Beach population in which spiders tended to occur in patches with density 5 to 10 times greater than in other populations. The mating season in the Coastal Range tends to be two months in duration, and adult females do not survive the summer. In Beach habitats the mating season tends to be eight months in duration, and adult females are present throughout the year. Phenology with more pronounced seasonal trends in the Coastal Range is correlated with greater seasonal fluctuations in climate. Beach habitats have relatively constant, mild climate. In Alpine habitats the mating season is restricted to summer months, when snow does not cover the ground. In the Rocky Mountains, summer rain is frequent; and the mating season extends through the entire summer (approximately 3 months). In the Sierra Nevada, summer rain is rare; and the mating season is restricted to early summer (approximately 1 month). Evidence from the field indicates that males do not survive the winter in Alpine habitats; and in laboratory experiments, adult males were inferior to adult females and immatures in their ability to survive simulated winter conditions. Possible causes of interpopulational differences in phenology are discussed; and hypotheses are discussed concerning the adaptive significance of iteroparity, oviposition of infertile eggs, inter- and intrasexual size variation, intersexual variation in longevity, and other life history characteristics.

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INTRODUCTION

In the family Salticidae there are more than 4000 described species (Prószyński 1971), but published life histories of only a few of these are available (Bailey 1968, Bonnet 1933, Crane 1948, 1950, Dondale 1961, Edwards 1975, Gardner 1965, 1967, Horner and Starks 1972, Miyashita 1969, Taylor and Peck 1974). This study concerns the life history of *Phidippus johnsoni* Peckham and Peckham, an abundant, euryecious salticid with a wide geographical range in western North America, studied in the laboratory and the field. Previous studies have dealt with varied aspects of the biology of this species (Dewey 1965, Enders 1975, Hill 1975, Jackson 1976, 1977a, b, 1978a, b, c), but not its life history. The evolution of life history tactics has become an important topic in biology (see Stearns 1976); and as a major group of predatory arthropods, spiders can be expected to provide valuable subjects for studies in this area.

Recently there has been increasing interest in the phenology (seasonal changes in population composition) of spiders (e.g. see Edgar 1972, Merrett 1969, Robinson *et al.* 1974, Vlijm and Kessler-Geschiere 1967). The phenology of *P. johnsoni* is of particular interest because in this species phenology varies from population to population. To a lesser extent, density is also subject to interpopulational variation. These trends will be discussed in relation to climatic and other habitat differences.

The distribution of *P. johnsoni* is bounded by the Great Plains, the Pacific Ocean, northern Mexico, and southern Canada. This species occurs from sea level to timberline, occupying relatively xeric habitats such as coastal dunes and oak woodlands. However, I am not aware of populations from desert habitats, and although *P. johnsoni* has been found in areas of fairly dense vegetation, I am unaware of populations from areas with extensive closed forest canopy. Spiders from six populations were involved in this study (Fig. 1).

The salticids are diurnal vagabond predators that stalk their prey with the aid of their highly developed visual system (Land 1972). Accurately determining the total number of individuals of a vagabond species in a given area, while the spiders are wandering about, is problematic. However, *P. johnsoni* constructs conspicuous silken nests (retreats) under rocks and wood on the ground and in other similar locations (Jackson 1978c). They remain inside these at night and during inclement weather. Molting, oviposition, and sometimes courtship and mating occur inside nests. *P. johnsoni* is relatively easily located in the field when occupying nests, and this was an important factor in making this study feasible.

Oviposition, postembryonic development, and other aspects of life history were investigated in the laboratory; and these data were used in conjunction with data from the field for a more intensive study of life history of spiders from Coastal Range habitats.

STUDY SITES

Phenology and density were studied in six populations (Fig. 1), and the spiders used in laboratory studies also originated from these populations: two from the Coastal Range of California, two from the Beach habitats (sea level, next to the ocean) in California, and two from Alpine habitats. Brief descriptions of habitats will be provided here (for more detail, see Jackson 1976). Munz's (1959) classification of California plant communities was used.

Tilden Regional Park — Coastal Range. Contra Costa County, California. Rocky, grass covered slopes. Elevation: 400-600 m. Plant community: Coastal Prairie. Primary nest sites: rocks.

Mount Diablo State Park — Coastal Range. Contra Costa County, California. Rocky, grass covered slopes. Elevation: 800-900 m. Plant community: Foothill Woodland. Primary nest sites: rocks.

Point Reyes National Seashore — Beach. Marin County, California. Sand dunes, ca. 100 m from the ocean. Elevation: sea level. Plant community: Coastal Strand. Primary nest sites: wood on the ground.

Inglennook Fen — Beach. Mendocino County, California. MacKerricher State Park, vicinity of Inglennook Fen (Baker 1972). Sand dunes and a bluff, ca. 100 m from ocean. Elevation: sea level. Plant community: Coastal Prairie and Coastal Strand. Primary nest sites: Wood on ground, fence posts, dead trees.

Pothole Dome — Alpine. Mariposa County, California. Sierra Nevada, Yosemite National Park. Open, rocky area on granite dome. Elevation: 2600-2700 m. Plant community: Lodgepole Forest. Primary nest sites: rocks.

Whiskey Mountain — Alpine. Fremont County, Wyoming. Wind River Range, Rocky Mountains. Extremely rocky slopes. Elevation: 3000-3400 m. Plant community: timberline, scattered Engelmann Spruce (*Picea engelmannii*). Primary nest sites: rocks.

Climate — Habitats differ in their temperature and precipitation patterns (see Elford 1970, Lowers 1960). California has a Mediterranean climate, with relatively hot, dry summers and wet, cold winters. However, the Beach habitats have more constant and mild climate than the Coastal Range. Temperature varies little during the year; and although rainfall is much less frequent during the summer, it occasionally occurs. Another important influence is coastal fog, which ameliorates the effects of reduced summer precipitation in Beach habitats. The Coastal Range is subject to greater fluctuations in rainfall and temperature. Winter temperatures are colder and summers are hotter. Rainfall virtually never occurs during the summer, and herbaceous vegetation typically turns brown. Summers would seem less severe in Beach habitats, where the herbaceous vegetation remains green all summer.

Snow is rare in the Coastal Range habitats, and it is virtually non-existent in the Beach habitats, but in the Alpine habitats it covers the ground during the majority of the year. Although active *P. johnsoni* have been found in all months of the year in the Beach and Coastal Range populations, they are presumably inactive for much of the year in Alpine populations. Compared to Pothole Dome, Whiskey Mountain has milder summers. Rainfall is common and the herbaceous vegetation is generally green all summer. Pothole Dome receives much less summer rain. As the summer progresses and moisture from melting snow decreases, the herbaceous vegetation turns brown.

METHODS

General — Unless otherwise noted, all selections of spiders and assignments to groups for experiments in the laboratory were carried out randomly (random numbers table: Rohlf and Sokal 1969). For all statistical tests, see Sokal and Rohlf (1969). Unless otherwise noted, data given in parenthesis in the text are means \pm S.D. Whenever it was necessary to touch spiders, eggs, or exuvia, a camel's hair brush was used.

Cages and Maintenance — Spiders in the laboratory were kept in cages constructed from $11 \times 8 \times 6$ cm clear plastic boxes (Jackson 1974). Each included a ventilation hole covered by a metal screen, three cork holes, and a cotton roll partially external to the cage. The cotton was kept wet in order to provide moisture in the interior of the cage. The spiders readily constructed nests in the corner of their cages. First through fourth instars were fed vestigial winged *Drosophila melanogaster*. Later instars were fed house flies (*Musca domestica*). *Drosophila* cultures were reared in glass shell vials that were partially inserted into the cages. Using this procedure, adult *Drosophila* were continuously emerging into the spiders' cages. When house flies were used, they were introduced through the cork holes as needed in order to maintain 3 to 8 flies in the cages at all times. For house flies, the shell vial connected to the cage contained sugar cubes on which the flies fed. Temperature was maintained at 23-25°C. In the study of postembryonic development, the light regime was 11L:13D. Otherwise it was 12L:12D.

Terminology — Following the terminology of Whitcomb (1978), the stage beginning with the rupture of the chorion and ending with the first true molt will be called the postembryo. The stage that follows the first molt is the first instar, and so forth. The postembryos are relatively inactive, lack functional chelicerae, and remain inside the nest. I will restrict the term "subadult" to the instar immediately preceding the final molt. Subadult females can be identified by the outline of the epigynum, which is visible beneath the cuticle of the ventral abdomen; and subadult males are identified by their enlarged palps. After hatching the immature spider undergoes a series of molts until it is mature, after which no more molting occurs.

Postembryonic Development — An inseminated female was collected from Mt. Diablo. She oviposited in the laboratory, and when the first instar spiderlings dispersed from the maternal nest, 39 were chosen for rearing. Each was placed in an individual cage, and more or less daily records were kept. Since these individuals were not separated until they had reached the first instar, they did not provide data concerning the duration of postembryos and first instars. Therefore, complementary observations were carried out on another two sets of spiderlings. These originated from females collected at Mt. Diablo as subadults and mated in the laboratory when they matured. Thirty eggs were chosen for observations on postembryos, and 30 postembryos from another female were selected for observations on first instars. For observations on postembryos, the nest another two sets of spiderlings. These originated from when they matured. Thirty eggs were chosen for observations on postembryos, and 30 postembryos from another female were selected for observations on first instars. For observations on postembryos, the nest was opened ten days after oviposition. Thirty eggs were placed individually in a 25mm diameter plastic dish. Once hatching occurred, the relatively immobile postembryos remained in the dish, and they were monitored each day until they molted or died. The dishes were kept inside a large plastic box, provisioned with moisture by four wet cotton rolls partially interior to the cage. For observations on first instars, a nest was opened three days after hatching occurred. The postembryos were placed in a 85 mm diameter plastic petri dish, inside a large plastic box provided with moisture. Monitoring the postembryos each day, whenever one molted, the first instar spiderling was placed in an individual cage and provided with *Drosophila*. The first instar spiderlings were monitored daily until molting or death occurred.

Oviposition and Hatching — Data concerning the number of egg batches oviposited came from 71 females collected in the field (Mt. Diablo, 14; Tilden, 57) as immatures, mated in the laboratory, and maintained until they died. Data concerning the number of

eggs per batch came from 30 of these (Mt. Diablo, 14; Tilden, 16). Each female mated a single time. These spiders were maintained until death or until they ceased to oviposit. After oviposition, the female's eggs could be seen through the silk of her nest, although a bright light was sometimes necessary. Two to seven days after oviposition, the females were forced out of their nests and transferred to clean cages. The nests containing eggs were placed inside 25 × 79 mm shell vials plugged with cotton, after cutting away much of the silk. The great majority of the eggs in a given batch hatched on the same day, and this day was recorded as the date of hatching. Since the postembryos could be seen either through the door of the nest or through the silk with the aid of a bright light, it was not necessary to open the nest in order to observe hatching. The day on which a mass exodus of spiderlings occurred was recorded as the day of nest departure in this study. This day could be recorded unequivocally, since the majority of the spiderlings inside a given batch departed on the same day.

Measurements — Body length was measured to the nearest 1 mm from the antero-medial eyes to the posterior end of the abdomen, excluding the spinnerets, using a ruler. Measurements on the carapaces were made to the nearest 0.01 mm under a microscope with an ocular micrometer. Terminology for carapace features is explained in Fig. 2. When the spider molted, its carapace was shed as a single plate. Carapace measurements were made on spiders as well as their exuvia, and there were no consistent differences when the two were compared. Carapace length was measured on exuvia only, since the posterior end of the plate was obscured by the abdomen on intact spiders. Since the locations of eyes were obscure on postembryos, only length and one width (W-PLE) were measured. For W-PLE the widest location on the carapace of the postembryo was used.

Survival Under Reduced Temperature Without Food — A set of spiders from Whiskey Mountain (Alpine) were placed inside an environmental chamber in the fall and removed between 4 and 5 months later. In the late spring, the experiment was repeated with a set from Tilden, Inglenook, and some other California habitats (Non-Alpine). Each spider was inside an individual cage, in which it constructed a nest. Beginning at 23°C, temperature was lowered 5°C each day until reaching 3°C. Temperature was kept at 2-4°C, and open pans of water maintained humidity inside the dark environmental chamber.

Censuses — Phenology data were gathered by monthly censuses at Tilden, Mt. Diablo, Inglenook, and Pt. Reyes, carried out over two successive years. Pothole Dome was censused each month during the season when there was no snow cover (June through October), for two successive years. For each population, a single location was chosen as a monthly census area according to the following criteria: (1) The area gave an impression of having a population density close to the maximum for the habitat. (2) There were conspicuous objects at the borders and especially the corners of the area, such as trees, fence posts, or boulders. (3) The area could be completely searched in approximately 2 to 3 hours.

Every month, each potential nest site was searched systematically. Since *P. johnsoni* were not found under rocks and pieces of wood less than 5 cm in length, these were checked only sporadically; all larger than this were checked each time. When a *P. johnsoni* was discovered, it was taken temporarily into a glass vial, plugged with cotton. After recording the spider's body length and life stage (adult female, adult male, immature), it was released. Measurements were made with a ruler held against the glass vial, the spider could be prevented from moving, when necessary, by adjusting the cotton plug so as to press the spider gently against the bottom of the vial.

Generally, successive censuses of a given population were made three to four weeks apart. Occasionally this was not possible, but the shortest interval was ten days. A fire destroyed the Pt. Reyes census area, before the last three censuses had been made. For this reason, Population Density Census Area No. 2, which had comparable density and area, was substituted for the final censuses at Pt. Reyes. More information concerning censusing methods is provided elsewhere (Jackson 1976).

At Tilden, Mt. Diablo, Inglenook, Pt. Reyes, and Whiskey Mountain, two population density censuses were made for each population. Except for Inglenook, which will be discussed later, Population Density Census Area No. 1 was the same area as the monthly census area. Area No. 2 was another similar area. Density censuses were carried out at a time close to the peak of the mating season for each population. The methods were the same as for the monthly censuses, except that the density censuses were carried out at sunrise, usually on rainy and relatively cold days. Under these conditions, it was reasonably certain that all spiders were in their nests. All wood in the census areas was broken open with a hatchet. For evaluation of density, all living individuals were counted except for masses of postembryos and first instar spiderlings inside nests.

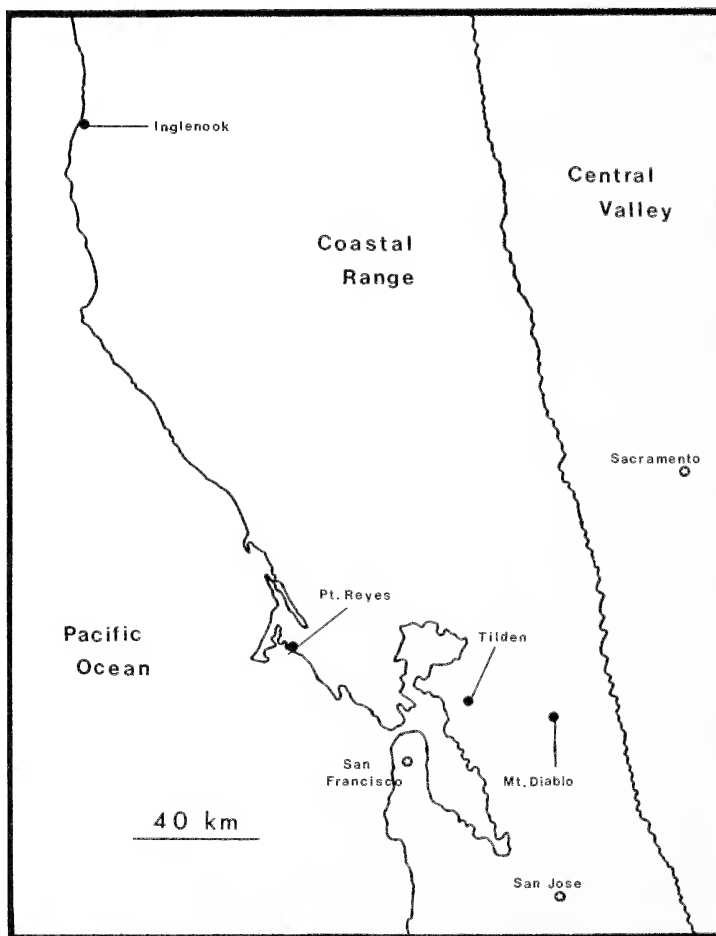


Fig. 1.—Map of northern California showing location of census areas. See Table 1.

OVIPOSITION AND HATCHING

Number of Batches — Fertile eggs are defined as ones that hatch, and a fertile female is one that oviposits any fertile eggs after copulation. A fertile batch is one containing any fertile eggs. Usually fertile batches contained some infertile eggs. Fertile females may oviposit infertile batches, which are ones that contain no fertile eggs. After copulation, infertile females either do not oviposit or they oviposit infertile eggs only.

Fertile females oviposited a series of one to five fertile batches (Table 1), sometimes followed by infertile batches; but infertile batches were never followed by more fertile batches. Some females oviposited only one fertile batch before beginning to oviposit infertile ones. Also, some females died before ovipositing any fertile batches. However, since disregarding these (Table 1, compare rows 3 and 4) does not appreciably elevate the mean number of fertile batches, death before completion of a full series of oviposition is apparently not the entire explanation for variability in the number of batches per female.

Oviposition by Infertile Females — Seventeen of 20 virgin females failed to oviposit. Two oviposited one infertile batch each, and one oviposited two infertile batches. A comparison of adult longevity of those virgins that failed to oviposit with the time between the final molt and the first oviposition of virgins that oviposited (Fig. 3) suggests

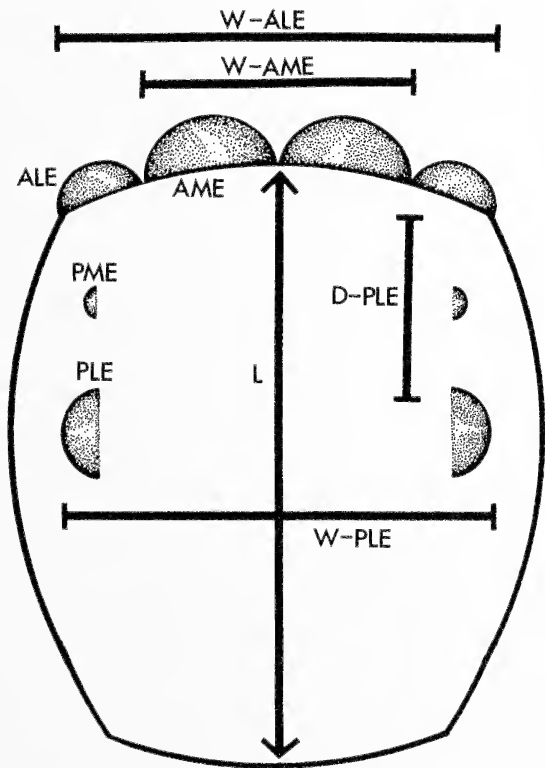


Fig. 2.—Carapace of *Phidippus johnsoni*. Eyes: anteromedial (AME), anterolateral (ALE), postero-medial (PME), posterolateral (PLE). Carapace features: distance from anterior edge of carapace, between the two AME, to posterior end of carapace (L); distance from lateral edge of one PLE to lateral edge of other (W-PL); distances between lateral edges of the two ALE (W-ALE) and the two AME (W-AME); distance measured from the posterior edge of AME to anterior edge of PLE (D-PL). See text for additional details.

that oviposition by virgins occurs at a time substantially after maturity, and that those virgins that failed to oviposit were generally ones that died before reaching this advanced age. Since a Mann Whitney U-test indicated that significance was approached but not reached ($0.10 > P > 0.05$), further data related to this question would be of interest.

Disregarding those females that died less than 40 days after copulation, 14 mated females failed to oviposit after mating, and 15 oviposited infertile batches only. The number of batches oviposited by infertile mated females (Table 1, compare rows 1 and 2) was fewer than the number oviposited by fertile mated females ($t = 4.356$, $P < 0.001$). Copulation seems to influence oviposition somehow, and it would be of interest to compare the mechanisms involved with those known for insects (Engelmann 1970, Leopold 1976). It is not known whether mated infertile females were inseminated. However, they did not behave the same as virgin females when the date of the first oviposition is considered (Fig. 3). More time elapsed between maturity and the first oviposition for virgin females than for mated infertile females (Mann Whitney, $P < 0.01$), suggesting that copulation influenced oviposition somehow even when mating did not produce fertile eggs. Oviposition by infertile females, including virgins, infertile batches from fertile females, and infertile eggs in fertile batches have been reported for other salticids (Edwards 1975, Horner and Starks 1972). Fertile females oviposit approximately 42 infertile eggs each (Table 1, rows 5 and 6), some of which tend to be in infertile batches and even more of which tend to be in fertile batches (Table 1, rows 7 and 8).

Number of Eggs and Hatch Proportion — Fewer eggs are oviposited in each successive batch of eggs (Fig. 4), as is frequently the case in spiders (Bristowe 1958). Also, the proportion of the eggs that hatch (hatch proportion) decreases with each successive batch as has been reported in other salticids (Edwards 1975, Gardner 1965, Horner and Starks 1972). The trend toward fewer eggs and smaller hatch proportions is indicated by linear regression (Fig. 4) and by performing a series of paired comparisons (t-tests). In the latter, each fertile batch of a given female was compared with her previous batch, and tests for each set of batches were significant ($P < 0.01$).

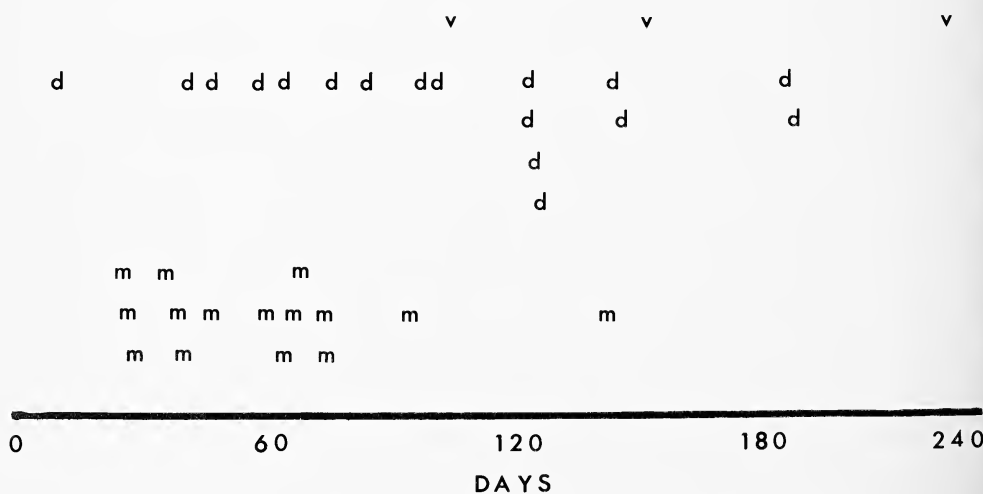


Fig. 3.—Oviposition by infertile females. Each point represents a different individual spider. Days: number of days elapsed since reaching maturity. *v*: First oviposition by virgin female. *d*: Death of virgin female that failed to oviposit. *m*: First oviposition by infertile, mated female.

Table 1.—Data related to oviposition. See text for definitions of “Fertile Batch” and “Fertile Female.” Note: Means \pm S. D. identical for digits expressed in rows 3 and 4.

	Mean \pm S.D.	Max.	Min.	n
1. Total number of batches oviposited by fertile females.	3.1 \pm 1.32	7	1	71
2. Number of batches oviposited by infertile mated females.	1.5 \pm 0.83	4	1	15
3. Number of fertile batches oviposited by fertile females.	2.6 \pm 1.14	5	1	71
4. Number of fertile batches oviposited by fertile females that oviposited at least one infertile batch.	2.6 \pm 1.14	5	1	29
5. Total number of eggs oviposited by fertile females.	207.9 \pm 81.84	355	68	30
6. Number of fertile eggs oviposited by fertile females.	165.5 \pm 63.40	309	64	30
7. Number of infertile eggs within fertile batches. (Females that oviposited at least one infertile batch.)	69.6 \pm 53.39	147	3	8
8. Total number of eggs within infertile batches. (Fertile females that oviposited at least one infertile batch.)	28.4 \pm 13.68	54	12	8

Timing of Oviposition — Approximately one month (24.8 ± 5.36 days) generally elapsed between copulation and the first oviposition by fertile females. The timing was more variable for infertile mated females (43.0 ± 25.85 days). Subsequent fertile oviposition followed at approximately one month intervals (30.0 ± 13.73 days), with infertile batches being oviposited after more variable periods (39.1 ± 27.52 days). In *Metaphidippus galathea* (Walckenaer), the interovipositional interval is 14.6 days (Horner and Starks 1972).

Hatching and Dispersal — Eggs hatch three weeks after oviposition (21.7 ± 1.56 days), and the first instar spiderlings disperse from the maternal nest after another three weeks (20.3 ± 1.52 days). In *Plexippus sitipes* Karsh (Miyashita 1969), the time between oviposition and hatching is similar (27 days), and the time between hatching and dispersal is very similar in *Phidippus coccineus* Peckham and Peckham (21 days, 7 females) (Gardner 1965). In *Phidippus regius* C. L. Koch (Edwards 1975) *P. coccineus* (Gardner 1965), and *Phidippus audax* (Bailey 1968), the time between mating and the first oviposition is very similar to that for *P. johnsoni*.

POSTEMBRYOLOGICAL DEVELOPMENT

Maturation Time — In the araneid spider *Araneus diadematus* Clerck, spiderlings within single batches fall into two groups, slow and fast developers (Ramousse 1973, Reed and Witt 1972), which require greatly differing time periods in order to obtain maturity in the laboratory under identical conditions. In the laboratory, some *P. johnsoni* reached maturity after a substantially shorter time than was the case for all other individuals (Fig. 5), suggesting that slow and fast developers occur in the Salticidae also, a group not closely related to the Araneidae.

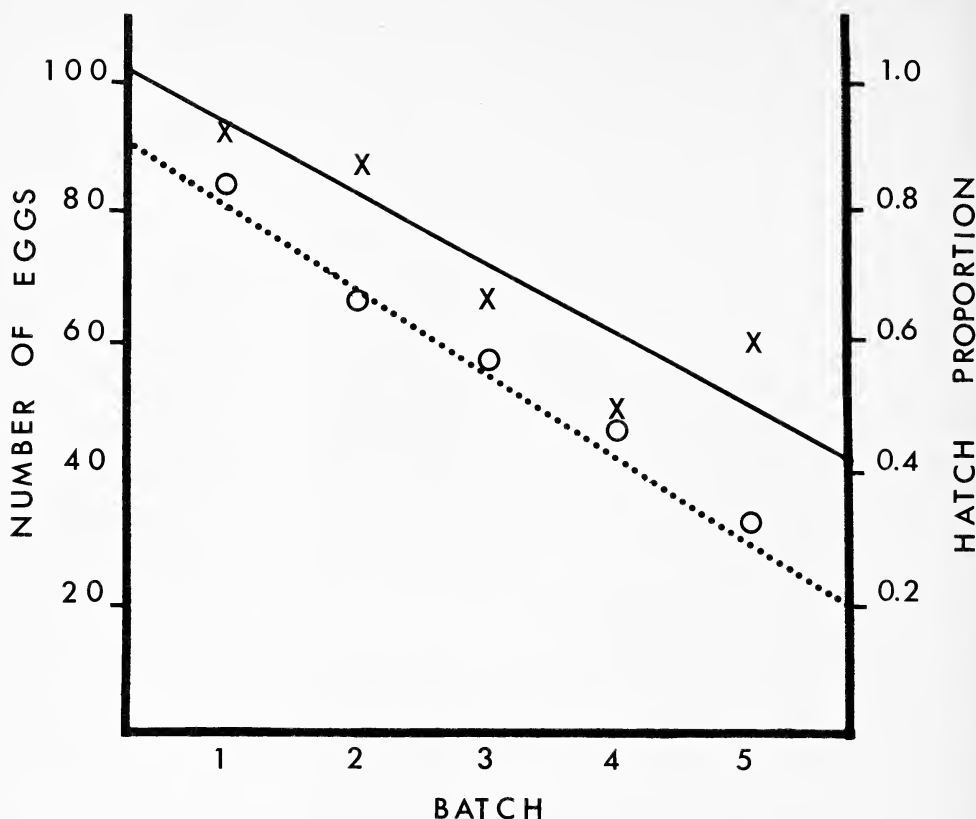


Fig. 4.—Decreasing size and hatch proportion (defined in text) of successive batches. Only fertile batches included. Both regression coefficients less than zero ($P < 0.001$). Linear regression equations: Batch size (dotted line), $Y = 92.87 - 12.07X$; hatch proportion (solid line), $Y = 1.07 - 0.12X$. Sample sizes: first batch, 30; second, 26; third, 20, fourth, 12; fifth, 4.

In the laboratory, maturation time was shorter for males than for females (Fig. 5) (Mann Whitney, $P < 0.001$). Earlier maturity of males was the pattern in phenology censuses also. Also when spiders were collected as subadults at Tilden and Mt. Diablo and taken to the laboratory, the males matured earlier than the females (Fig. 6) (Mann Whitney, $P < 0.001$). Horner and Starks (1972) reported shorter time between hatching and maturity for 18 male *Metaphidippus galathea* (180.5 ± 21.92 days) compared to 12 females (193.2 ± 25.00 days). The standard deviations were calculated from the 95% confidence limits for the means that they provided. However, assuming that their data were normally distributed, a t-test did not indicate that their means were significantly different.

Levy (1970) proposed that spiders fall into two groups with respect to life cycles. One group consists of species for which the males and females mature after a period of time and a number of molts such that spiders originating from the same egg batch overlap in time when mature. The other group consists of ones for which males have sufficiently fewer molts than females such that they do not overlap and siblings from the same batch cannot mate with each other. *P. johnsoni*, like the majority of spiders that have been

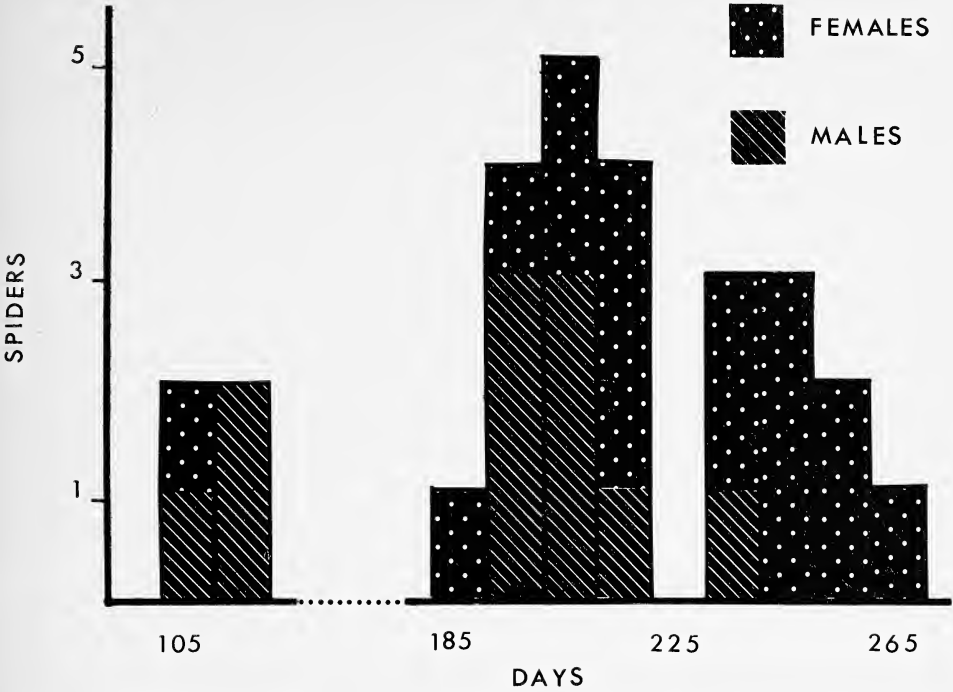


Fig. 5.—Comparison of female and male maturation time in the laboratory. Maturation time: number of days elapsed between hatching and maturity. Recorded in graph for 10-day intervals (105 represents 101-110 days, etc.).

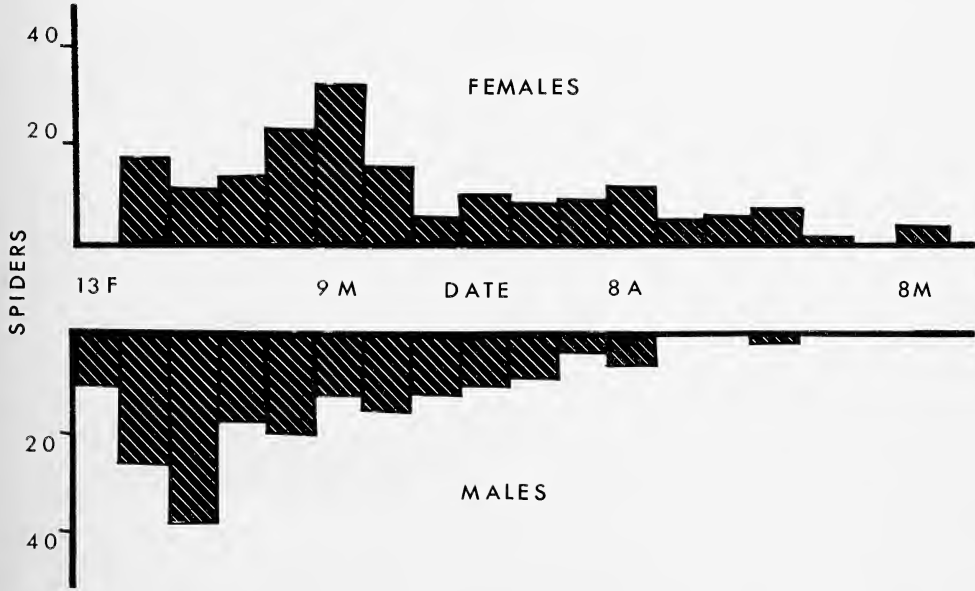


Fig. 6.—Comparison of female and male maturity date. Spiders collected as subadults at Tilden and Mt. Diablo. Matured in laboratory. Maturity date: day on which spider reached maturity. Recorded in graph for 5-day period (13 February represents 11 Feb.-15 Feb., etc.).

investigated, belongs to the first group. Robinson and Robinson (1978) have suggested that the second group is more prevalent in the tropics.

Spiders from the laboratory matured earlier than those from the field (compare Fig. 6 and 7) (Mann Whitney, $P < 0.001$). Gardner (1967) reported earlier maturity of laboratory reared *P. coccineus* compared to ones in the field. More plentiful food, higher temperatures, different light regimes, and other factors might be involved.

Number of Molts — In the laboratory, males of *P. johnsoni* molted fewer times before reaching maturity compared to females (Table 2). The shorter maturation time of males (Fig. 5) is related to this difference. Although a Mann Whitney test on these data does not indicate a significant difference, significance was approached; and when the data from the field, involving a greater number of spiders, is considered, there is a significant difference ($P < 0.001$) in the number of times females and males molt before reaching maturity.

There is also considerable intrasexual variation in the number of molts before maturity (Table 2). Intra- and intersexual variation in the number of molts before maturity, with males maturing in fewer molts occurs also in *Phidippus audax* (Taylor and Peck 1974), *Phidippus regius* (Edwards 1975), and *Philaeus chrysops* Poda (Bonnet 1933). The data of Bonnet, Edwards, and Taylor and Peck are summarized in Table 2, and Mann Whitney tests were carried out. The number of molts for males compared to females differs

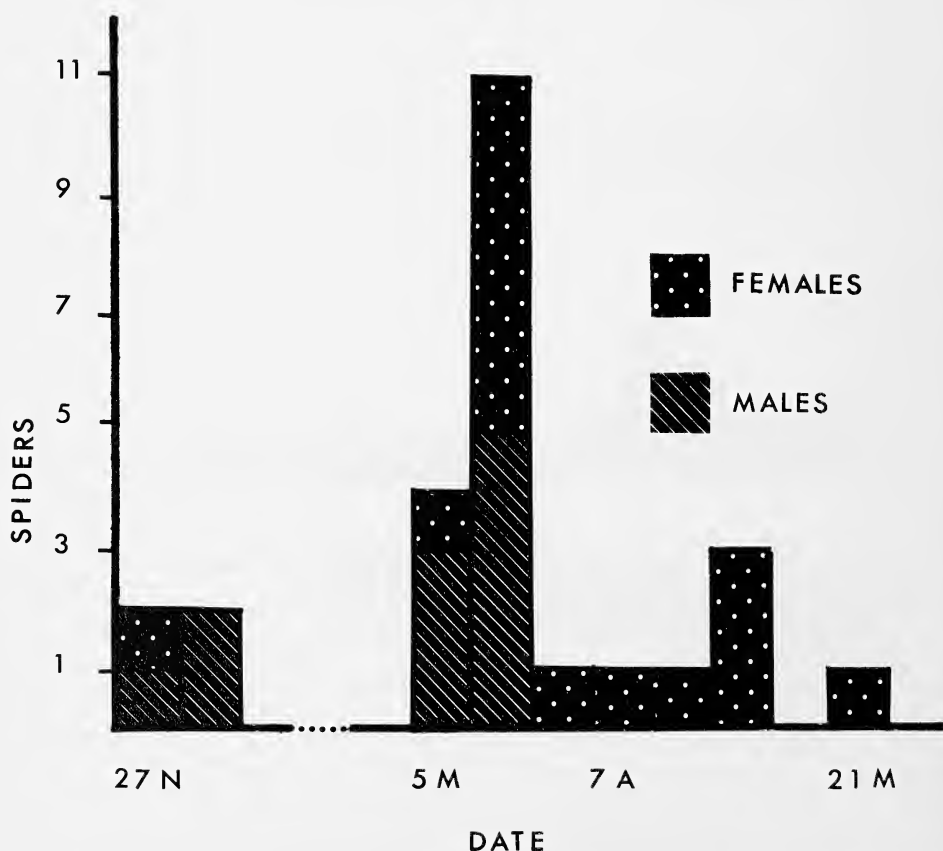


Fig. 7.—Comparison of female and male maturity date (defined in Fig. 6) of spiders reared from eggs in laboratory. Recorded in graph for 11-day periods (27 Nov. represents 22 Nov. -2 Dec., etc.).

Table 2.—Number of individuals of *Phidippus johnsoni*, *Phidippus audax*, *Phidippus regius*, and *Philaeus chrysops* that matured after different numbers of molts. Lab: spiders reared from eggs in laboratory. Field: spiders collected as large immatures at Tilden and Mt. Diablo. Data for *P. audax* from Taylor and Peck (1974); *P. chrysops*, Bonnet (1933); *P. regius*, Edwards (1975).

SPECIES	SEX	LOCATION	NUMBER OF MOLTS BEFORE MATURITY						
			5	6	7	8	9	10	11
<i>P. johnsoni</i>	Male	Lab	1	6	6	2	0	0	0
		Field	0	2	20	43	0	0	0
	Female	Lab	0	6	8	4	0	0	0
		Field	0	0	3	71	15	0	0
	Both	Lab	1	12	14	6	0	0	0
		Field	0	2	23	114	15	0	0
<i>P. audax</i>	Male	Lab	0	0	3	6	0	0	0
	Female	Lab	0	0	1	2	17	0	0
<i>P. regius</i>	Male	Lab	0	0	0	5	22	8	0
	Female	Lab	0	0	0	1	13	12	1
	Both	Lab	0	0	0	6	35	20	1
<i>P. chrysops</i>	Male	Lab	0	3	5	0	0	0	0
	Female	Lab	0	0	7	1	0	0	0
	Both	Lab	0	3	12	1	0	0	0

significantly for the laboratory data from *P. audax* ($P<0.001$) *P. regius* ($P<0.05$), but not for *P. chrysops*. It is apparently a common phenomenon in spiders for the male to mature after fewer molts than females (Bristowe 1958).

Duration of Instars — The durations of the postembryo stage and the first four instars tend to be only a few weeks (17.0 ± 2.14 days) (Table 3). Later immature instars tend to be longer (60.6 ± 38.75 days) (Mann Whitney, $P<0.05$). Later instars are also more variable, as indicated by the coefficients of variation (means 12.1 for postembryo through instar 4; 61.2 for instars 5 and 6; Mann Whitney, $P<0.05$). The subadult instar tended to be relatively long in duration. The postembryo showed especially little variation in duration, being 16 days for each spider. In *P. regius* (Edwards 1975), the postembryo was consistently 14 days in duration. Later instars were of increasing duration. Both Miyashita (1969) and Horner and Starks (1972) reported great variability in instar duration in the salticids they reared, and other investigators (Horner and Starks 1972, Taylor and Peck 1974) reported greater variation in later instars.

Bonnet (1930) pointed out a relation between adult body size of spiders and the number of preadult molts. Spiders measuring 8 to 11 mm when adults tend to molt 7 or 8 times, which is consistent with the data for *P. johnsoni* (Table 2).

Table 3.—Duration (days) of instars of immature spiders. "Subadult" defined in text. Spiders that died during the instar are excluded.

INSTAR	MEAN \pm S.D.	Max.	Min.	n
Postembryo	16.0 \pm 0.00	16	16	29
1st instar	19.5 \pm 2.37	24	16	29
2nd instar	14.7 \pm 2.46	20	12	37
3rd instar	15.7 \pm 2.01	20	13	36
4th instar	19.3 \pm 3.53	30	15	34
5th instar	50.8 \pm 39.00	159	17	32
6th instar	79.0 \pm 36.00	136	24	17
7th instar	74.3 \pm 6.03	80	68	3
Subadult	83.1 \pm 36.18	145	19	26

Body Size — Compared to the distensible abdomen, which changes in size with feeding within a single instar, the cephalothorax is rigid with its size remaining relatively constant during a single instar. Numerous authors (salticids: Bailey 1968, Crane 1948, Dondale 1961, Edwards 1975; see Hagstrum 1971, for references concerning other spider families) have used measurements from the carapaces of spiders as indicators of instar size. When the coefficients of variation for the five features measured on the carapaces of *P. johnsoni* are compared, there is no indication that different features are more variable than others. Also there is no indication that variability changes with instar. For each feature, overlap tends to occur in the later instars but not in the earlier ones (Table 4, Fig. 8).

Because the abdomen is distensible, body length was highly variable, even for the same individual during the same instar. Abdomen sizes were defined as follows: the diameter of a slender abdomen is conspicuously less than that of the cephalothorax; and the diameter of a fat abdomen is conspicuously greater than that of the cephalothorax. Fat abdomens were especially common on gravid females. After oviposition, body length often changed dramatically. For example, a ninth instar female may be as much as 15 mm in body length when gravid, but only 11 mm after oviposition. Immatures were prone to have fat abdomens before molting and slender ones afterwards, although changes in body length were usually less dramatic than in the case of ovipositing females. Adult males never had

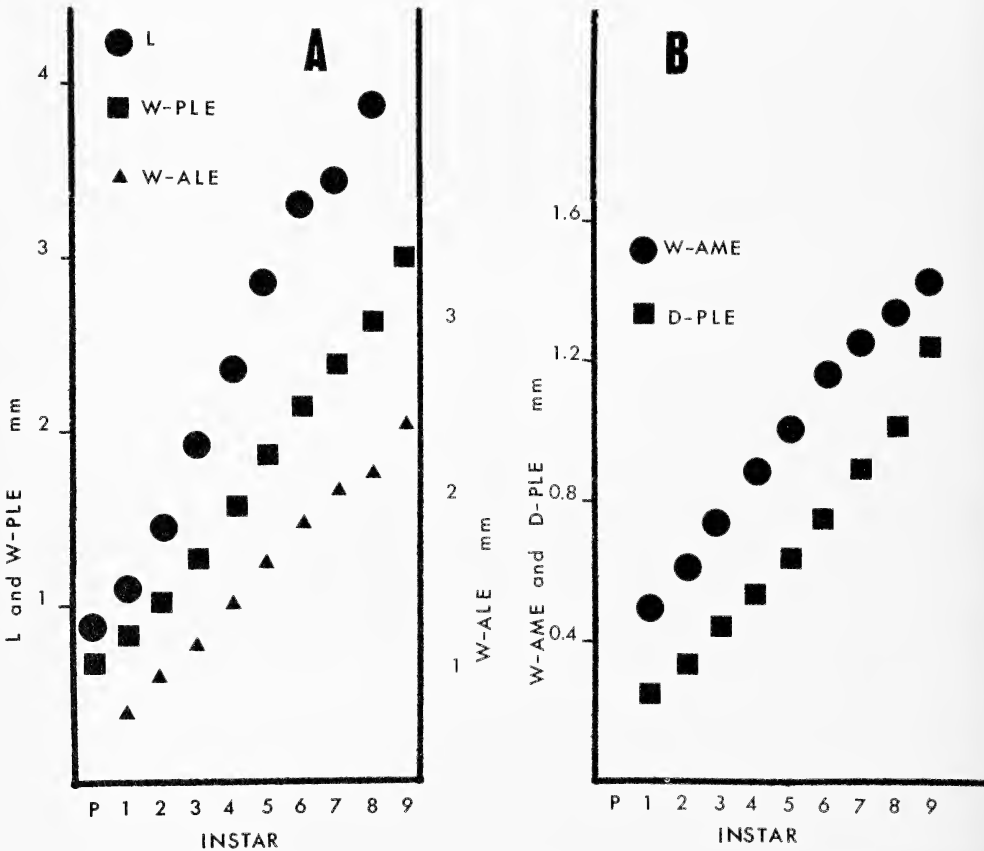


Fig. 8.—Relation between carapace features (defined in Fig. 2) and instar. Each point represents a mean. See Table 4 for sample sizes and coefficients of variation.

Table 4.—Variability and overlap of carapace features (defined in Fig. 2) of different instars (Pe: postembryo) C. V.: coefficient of variation. For a given instar, overlap occurs (indicated by +) if the mean minus one S. D. of the instar is less than the mean plus one S.D. of the previous instar. N: number of spiders measured. (*, not recorded).

Carapace Feature		Instar									
		Pe	1	2	3	4	5	6	7	8	9
L	C.V.	3.26	2.42	6.94	5.03	5.45	5.40	4.48	3.78	4.09	*
	Overlap	*	0	0	0	0	0	0	+	+	*
	N	10	18	24	26	26	28	16	52	12	*
W-PLE	C.V.	1.49	2.07	4.14	4.34	5.36	4.96	5.59	5.91	7.64	4.25
	Overlap	*	0	0	0	0	0	0	0	0	0
	N	10	33	25	27	28	31	28	16	55	12
W-ALE	C.V.	*	2.82	4.22	4.20	3.52	3.03	4.32	4.01	6.30	4.53
	Overlap	*	*	0	0	0	0	0	0	+	0
	N	*	33	25	27	28	31	28	16	55	12
W-AME	C.V.	*	2.01	3.99	4.27	3.37	2.96	3.86	4.10	5.32	2.15
	Overlap	*	*	0	0	0	0	0	+	+	+
	N	*	33	25	27	28	31	28	16	55	12
D-PLE	C.V.	*	3.90	5.14	3.18	3.24	3.90	10.43	7.95	12.72	6.49
	Overlap	*	*	0	0	0	0	0	+	+	0
	N	*	33	25	27	28	31	28	16	55	12

fat abdomens. Postembryos and first instars tended to have body lengths of approximately 2 mm; second instars, 4 mm; third, 6 mm; fourth, 7 mm; fifth, 7 to 8 mm; sixth, 8 to 12 mm; seventh, 8 to 13 mm; eighth, 10 to 14 mm; and ninth, 11 to 15 mm.

Instars of Spiders in Nature — As for the laboratory-reared spiders, adult males from the field tend to be smaller than adult females (Table 5). These spiders were collected as adults or subadults at Mt. Diablo. From the measurements made on each spider, a judgement was made for each concerning the instar to which it belonged. For spiders that were collected as subadults, the subadult exuvium was measured in addition to the spider. When all measurements were compared with the means and standard deviations for laboratory reared spiders of known instar (Fig. 8), there was one instar that each field-collected spider resembled most in size. The spider was judged to belong to this instar. No single measurement was adequate alone, as was also the case in Edgar's (1971a) study of lycosid life history. Determination of instars of spiders from the field was based on an assumption that the relation between size and instar for laboratory-reared spiders is applicable in nature. The accuracy of this assumption cannot be determined with data presently available.

Males in the field, as in the laboratory, seem to mature after fewer molts than females (Table 2) (Mann Whitney, $P < 0.001$). Earlier maturity, fewer molts before maturity and smaller adult size of males compared to females is a rather general trend in spiders

Table 5.—Sexual dimorphism. Carapace features defined in Fig. 2. Measurements: mean \pm S.D. (mm). All t-values, $P < 0.001$. Sample sizes: females, 63; males, 41.

CARAPACE FEATURE	FEMALES	MALES	t
W-PLE	2.8 \pm 0.20	2.4 \pm 0.16	10.044
W-ALE	2.2 \pm 0.16	2.0 \pm 0.12	8.123
W-AME	1.3 \pm 0.08	1.2 \pm 0.07	7.511
D-PLE	1.1 \pm 0.12	0.9 \pm 0.10	8.169

(Bonnet 1930, 1933, Bristowe 1958, Juberthie 1954, Levy 1970, Peck and Whitcomb 1970). *P. johnsoni* from the field tend to be larger than those reared in the laboratory, possibly because they molt more times before reaching maturity.

LONGEVITY AND MORTALITY

Survival of Immatures — The proportion of laboratory-reared spiders that survived for the duration of each instar varied little, and it was relatively great for each (Table 6). Overall survivorship from hatching to maturity was relatively high in the laboratory. Nine spiderlings involved in the study of postembryonic development either escaped, were accidentally killed, or were intentionally killed and preserved as representatives of each instar. Of the 30 remaining spiderlings, only four died before they reached maturity. In contrast, Bonnet (1933), Edwards (1975), Gardner (1965), Horner and Starks (1972), and Miyashita (1969) reported relatively higher mortality among salticid immatures, as seems generally true in studies of spider postembryonic development (e.g. see Bonnet 1930, Deevey and Deevey 1945). There may be a number of reasons for the relatively high survivorship of *P. johnsoni* in this study. The rearing procedure, providing continual food and moisture, was different from that used in other rearing studies, suggesting that this procedure may be particularly useful, at least for some species. Another factor may be that the prey provided (Diptera) are known to be an important part of the diet of *P. johnsoni* in the field (Jackson 1978a). Although some spiders evidently require considerable variety in their diet during development (Miyashita 1968), Diptera alone are adequate for survival of *P. johnsoni* in the laboratory. Suzuki and Kiritani (1974) showed that a varied diet can affect fecundity in spiders, and this has not yet been investigated in *P. johnsoni*.

Comparison of Male and Female Adult Longevity — Adult spiders tend to survive 3 to 4 months in the laboratory, with females surviving longer (126 ± 58.3 days) than males (94 ± 47.7 days; $t=4.079$, $P<0.001$). There also is evidence from the phenology censuses that male longevity is shorter than that of females in nature. Greater longevity of females in the laboratory compared to males has been reported in *P. coccineus* (Gardner 1965), *P. audax* (Bailey 1968), and in spiders from other families (e.g., see Bonnet 1930, Deevey and Deevey 1945). Assuming the data of Horner and Starks (1972) are normally distributed, the differences in longevity between females (222 ± 72.6 days, 20 females) and males (184 ± 77.4 days, 20 males) is not significantly different, although we may expect a difference if the sample size were increased.

Mortality in the Laboratory — When a dead or dying spider was seen in the laboratory, casual observations were made of the spider's behavior, location, and condition. A few spiders were accidentally or intentionally killed, and one that had been collected from the field died in the laboratory as a result of parasitization by an acroserid fly. Otherwise, the cause of death in the laboratory was unknown. Among both those spiders used in observations of postembryonic development and numerous others reared from immatures collected from the field, death of immatures frequently occurred during molting. Edwards (1975) reported that most deaths he witnessed in the laboratory involved spiders that were molting, and this seems to be a particularly vulnerable time for spiders (Turnbull 1973).

The appearance of the dead spiders varied greatly. In some cases, the spider's abdomen was collapsed, and its legs were curled under its body. This was true of all spiders that

Table 6.—Survival rates of immature spiders (Pe: postembryo).

INSTAR OF IMMATURE	Pe	1	2	3	4	5	6	7
NUMBER OF SPIDERS	30	30	37	36	35	33	15	3
PERCENTAGE THAT SURVIVED TO NEXT INSTAR	97	97	100	100	97	97	93	100

died during molting, for example. Dessication would seem to be involved in these deaths, although the causes of dessication are not known. However, other dead spiders did not have collapsed abdomens, and some females had greatly distended abdomens. Dead spiders without collapsed abdomens sometimes had their legs curled under their bodies, but others had legs extended stiffly perpendicular to the body. In some cases, spiders were lethargic for a day or more before death, moving sluggishly when prodded with a brush. In other cases, spiders seemed normal as shortly as one hour before death. Two spiders were found dead with flies held in their fangs, apparently having died while feeding. The great majority of dead spiders were found outside their nests.

PHENOLOGY

General Comments — The data for the two years are summed at each month for each population (Fig. 9-13), since the data for each year showed virtually the same pattern. Also, these patterns are consistent with more casual observations outside the monthly census areas, both at these habitats and at other similar habitats. The “mating season” is the time period during which adult males and females are simultaneously present in the field, confirmed by observation of courting or mating pairs in the field during each of these months.

The immatures are classified into two groups: ones less than 6 mm in body length, probably first through third instars; and ones greater than 6 mm, probably belonging to the fourth and later instars. As in the laboratory, males in nature mature earlier than females, at least in the Coastal Range. In the censuses, there was a preponderance of males at the beginning of the mating season. Also, I spent many days at Mt. Diablo and Tilden previous to the mating season, collecting spiders in areas other than the census areas. Many adult males, especially ones in nests with exuvia, were found previous to finding the first newly matured females.

Comparison of Beach and Coastal Range — Beach and Coastal Range populations have distinctly different phenologies (compare Fig. 9 and 10 with Fig. 11 and 12). In the Coastal Range, there was a short mating season, a month or two in duration. In contrast, the mating season in Beach populations extended through two thirds of the year. In the Coastal Range, the subadults matured nearly synchronously in the spring. At Beach habitats, subadult males and females matured throughout the prolonged mating season. The more pronounced mating season in the Coastal Range is probably an adaptation to the more seasonal climate in the Coastal Range.

Primarily wood was searched in the Beach habitats. Except during the density censuses, the small crevices in wood were not broken open and searched for spiders. Comparing density (Table 7) with phenology census data (Fig. 11 and 12) suggests that had wood been thoroughly searched in this way each month, a greater proportion of immatures 6 mm or less in length would have been uncovered, but the other categories would have been only negligibly affected.

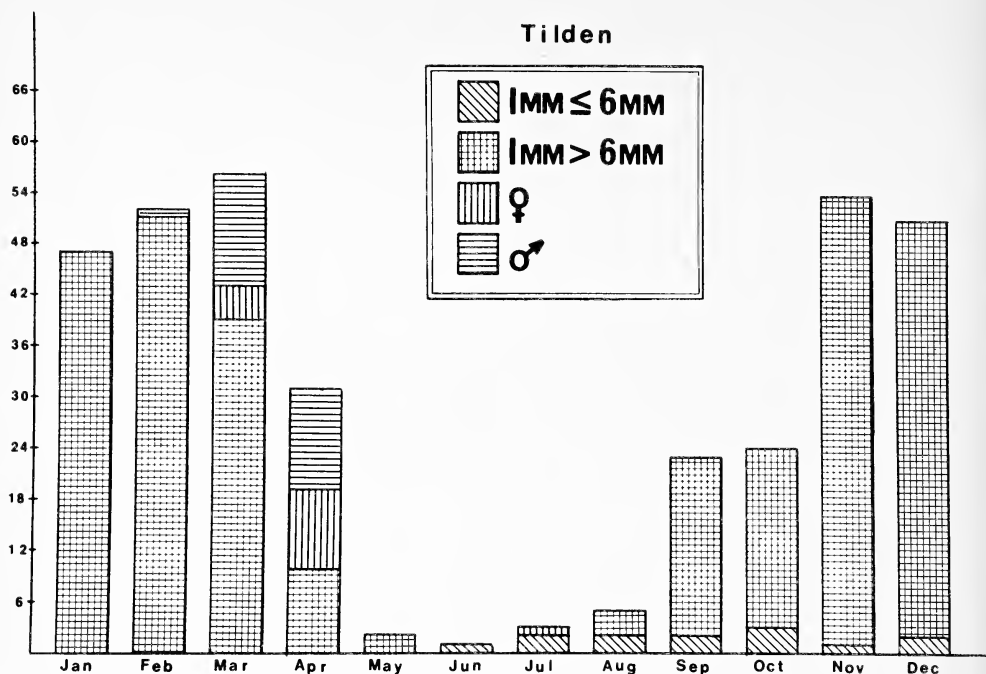


Fig. 9.—Phenology at Tilden Regional Park, Contra Costa Co., California. Number of individuals found during monthly censuses. Sum of data for two years.

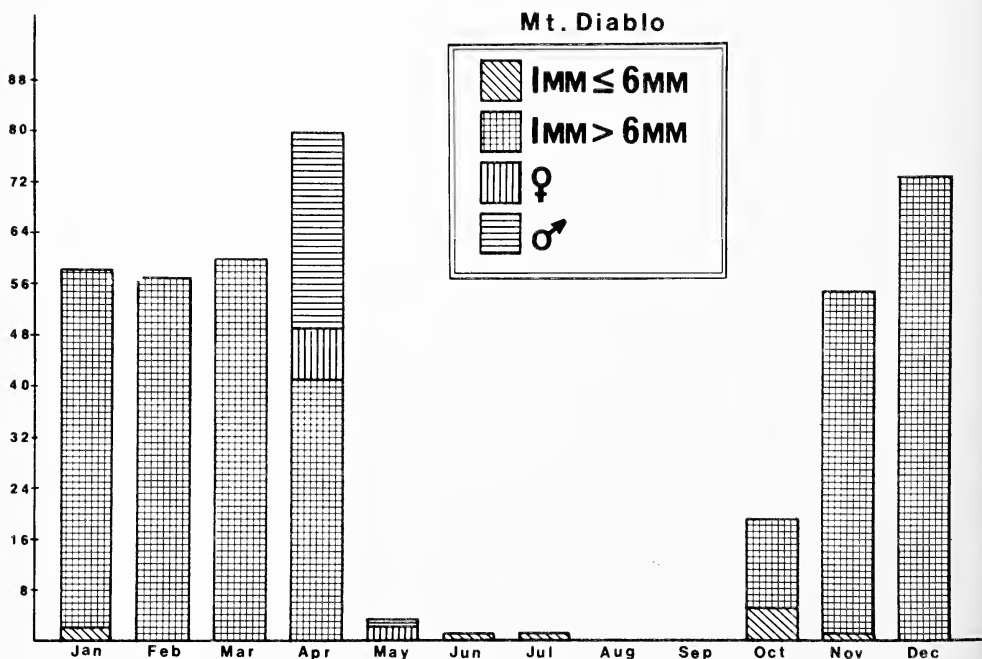


Fig. 10.—Phenology at Mt. Diablo State Park, Contra Costa Co., California. Number of individuals found during monthly censuses. Sum of data for two years.

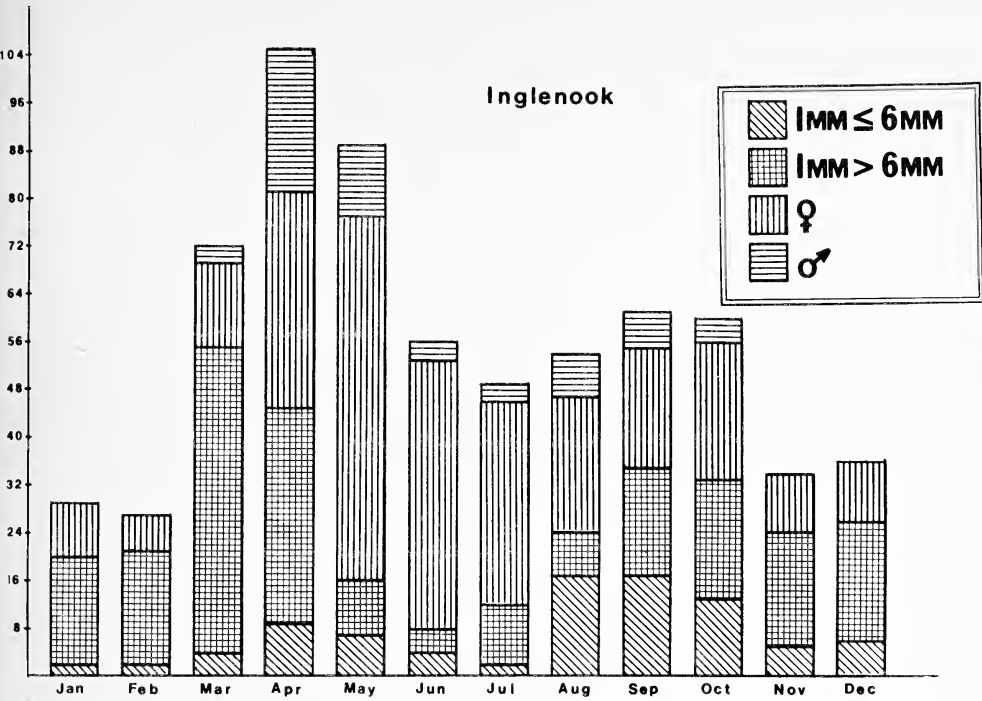


Fig. 11.—Phenology at Inglenook Fen, Mendocino Co., California. Number of individuals found during monthly censuses. Sum of data for two years.

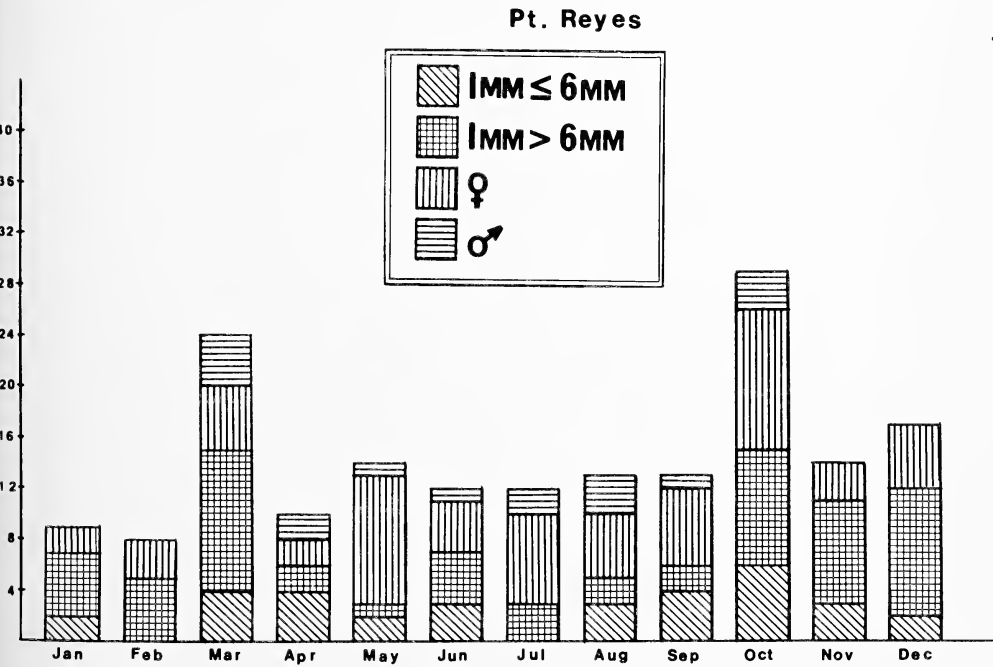


Fig. 12.—Phenology at Pt. Reyes National Seashore, Marin Co., California. Number of individuals found during monthly censuses. Sum of data for two years.

At Tilden (Fig. 9) and especially at Mt. Diablo (Fig. 10) *P. johnsoni* largely disappeared from the census areas during the summer. The small immatures spend the summer in shrubs and trees in the vicinity, from which they can be readily extracted by beating the limbs over a piece of cloth or a wire screen and in which they can be found, occasionally, occupying nests. However, immatures were not found in the shrubs and trees at other times of the year. Also, adults were rarely found in shrubs and trees. Probably the longevity of adults, especially males, is short in the summer in the Coastal Range, since few were found at this time. There is no evidence that any adult females survive the long period between mating seasons in the Coastal Range. Only a few adult females survive this long in the laboratory, with continuous food and moisture and mild temperatures. On the other hand, many females in the Beach populations apparently survive the brief period between mating seasons in these habitats.

Alpine Populations — It was not possible to carry out monthly censuses at Whiskey Mt., but using other information a probable hypothesis can be proposed concerning phenology. I visited Whiskey Mt. three times, each time during a different year and month (June, July, August). In July and August, I found immatures, adult males and adult females. In June, snow still covered the ground in some places, and it had only recently melted in the areas searched. At this time adult females and immatures of all sizes were present, but no adult males were found. However, when subadult males collected at this time were taken to the laboratory, they soon matured. At approximately the same time of the year, adult males were found at Blacktail Butte, a lower elevation site (2100 m) in Grand Teton National Park, Wyoming, which is at approximately the same latitude as Whiskey Mountain. Based on these observations, it seems likely that males mature soon after the snow melts on Whiskey Mountain and that the mating season extends through the summer until the next winter's snow arrives.

The phenology at Whiskey Mountain apparently contrasts with that at Pothole Dome (Fig. 13), where there is a very short mating season only a few weeks in duration, at the

Pothole Dome

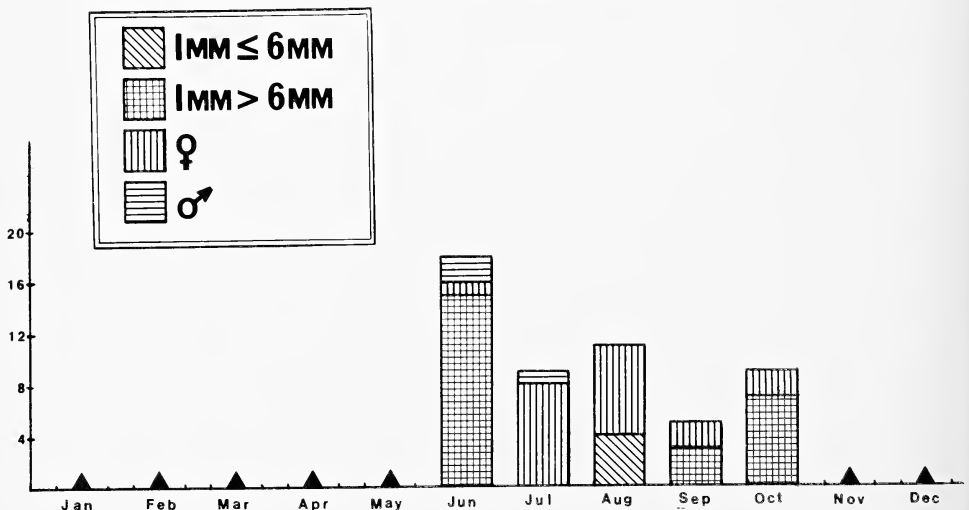


Fig. 13.—Phenology at Pothole Dome, Mariposa County, California. Number of individuals found during monthly censuses. Sum of data for two years. Ground covered by snow during months marked by triangles.

Table 7.—Population densities in different habitats. Number of nest sites (rocks and pieces of wood 5 cm or more in length) in each census area estimated by counting those in a randomly chosen sector. Inglenook Census Area No. 1 consisted of the monthly census area (A) plus an additional contiguous area (B). In Inglenook Census Area No. 2, there were only 4 pieces of wood (A: area covered by wood; B: remaining area). Number of nest sites not estimated for Whiskey Mountain Census No. 2. Only one census carried out at Pothole Dome.

CENSUS	INGLENOOK			POINT		MT.	WHISKEY	POTHOLE
	A + B	A	B	REYES	TILDEN	DIABLO	MT.	DOVE
NUMBER 1								
Area (M ²)	51,327	1974	49,353	1923	4181	5574	1431	1328
Spiders per 1,000 M ²	2.41	34.45	1.13	8.31	6.93	6.46	3.49	6.77
Spiders per 10,000								
nest sites	347.33	416.66	288.95	36.23	191.79	169.01	8.40	21.64
Area of Sector (M ²)	1510			84	232	279	41	51
NUMBER 2								
Area (M ²)	455	61	394	2044	5806	3716	6967	
Spiders per 1,000 M ²	65.90	490.77	0	5.38	10.68	8.34	6.89	
Spiders per 10,000								
nest sites				35.71	216.78	234.84		
Area of Sector (M ²)				93	290	186		

beginning of the summer. Again males seem to mature soon after the snow melts in the early summer. During both years an extra census was carried out at Pothole Dome very soon after the snow melted, a week or two previous to the census reported for June in Fig. 13. Although numerous adult females and immatures were found, only two adult males were present. These males had probably just molted since they were in nests with exuvia. As in the Coastal Range, males vanish later in the summer, as conditions become more xeric. Conditions do not become so xeric on Whiskey Mountain, and the contrast in phenology seems to be a reflection of this climatological difference.

Oviposition in Nature — The months during which oviposition occurs correspond approximately with the mating season (Table 8). Eggs, postembryos, and/or first instar spiderlings inside nests were found either during the phenology censuses or in neighboring areas during most of the year in the Beach habitats and throughout the summer in Alpine habitats. The egg shells found at Pothole Dome in May and at Whiskey Mountain in June were in unoccupied nests. These were perhaps remains from batches oviposited in previous summers. The relatively few eggs, postembryos, and masses of first instar spiderlings in nests in the Coastal Range were found in the early summer. A possibility that needs consideration is that ovipositing females go under very large boulders that I could not overturn by hand. Heat and desiccation would present less severe conditions in these locations. Also, they might go into holes in the ground. This was suggested by an adult female with eggs found in a hole containing a bumble bee (*Bombus*) nest (Charles Griswold, pers. comm.).

DENSITY

General Comments — Apparently few, if any, spiders were missed by the density census methods. In the case of one of the Tilden censuses, I collected each *P. johnsoni* that was found. When the area was searched again the next day, no additional *P. johnsoni* were discovered.

Table 8.—Seasonal occurrence of oviposition in different populations. Census (phenology census area; see text): counted number of nests found containing eggs, postembryos, and/or masses of first instar spiderlings. Nests containing egg shells, but no living progeny given in parentheses. Other (sites in the vicinity of the census areas): only qualitative data available. Presence: +; absence: -. Pothole Dome not visited November to April; Whiskey Mountain not visited September to May. No monthly censuses made at Whiskey Mountain. No progeny or egg shells found at Mt. Diablo, Tilden, Pt. Reyes and Inglenook in January, February, November and December.

POPULATION		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Mt. Diablo	Census	0	0	0	0	0	0	0	0
	Other	—	—	+	+	—	—	—	—
Tilden	Census	0	0	2	0	1	0	0	0
	Other	—	—	+	+	—	—	—	—
Pt. Reyes	Census	0	0	1	4	1	1(1)	1(5)	1(2)
	Other	—	—	+	+	—(+)	+(+)	—	—(+)
Inglenook	Census	0	0	3	8(4)	6(44)	10(20)	0(8)	2(2)
	Other	+	+	+(+)	—	+(+)	+(+)	+	+(+)
Pothole Dome	Census			0	0(1)	0	0	0	0
	Other			—(+)	+(+)	+	+(+)	+	—
Whiskey Mountain	Other				+(+)	+(+)	+(+)		

Except for Inglenook, densities calculated with respect to area are quite similar (Table 7). However, density varies greatly with respect to number of nest sites.

Patchiness — At Inglenook the phenology census area was a 260 × 8 m rectangle along one side of a fence which enclosed cattle. The cattle were on the opposite side of the fence from the census area. All other density census areas were more nearly square in shape. In order to obtain a more nearly square area at Inglenook Census Area No. 1, the area searched was extended beyond the phenology census area to a parallel fence at the opposite side of the pasture. This was a very heterogeneous area with respect to nest sites. Wood was concentrated near the fences, especially in the vicinity of the monthly census area. Comparing density inside the phenology census area with that for the remainder of Census Area No. 1, the difference is dramatic (Table 7). Census Area No. 2 for Inglenook was an area containing four dead trees on the ground. Again, a very heterogeneous area was censused. In Table 7, the density of Area No. 2 as a whole can be compared to the density calculated for the approximately 61 m² liberally estimated as the area covered by the dead trees. All spiders in this census were found on the dead trees. In summary, spiders occurred at Inglenook censuses in patches in which density could be five to ten times greater than at the other census areas. Census areas at the other habitats were rather homogeneous with respect to nest sites. These trends seemed to apply not only to the census areas but generally within the habitats.

Table 9.—Survival of spiders under reduced temperature and without food. Frequencies with which males survived compared (chi square tests of independence) with those for female and immatures. (*, P <0.05; **, P <0.005).

Spiders: Population of Origin	Survived	Females	Males	Immatures
Alpine	Yes	11	0	67
	No	2*	3	46*
Non-Alpine	Yes	71	3	
	No	16**	29	

Another characteristic of Inglenook is that patches containing nest sites and spiders tended to occur as islands in the sense that distances greater than the width of the patch frequently separated it from other patches. Patches occurred at clumps of trees, along wood fences, and at other such places, separated by open sand dunes, open prairies, or other unsuitable space. This was also true of Pt. Reyes to a lesser extent. In contrast, in other habitats space containing nest sites and spiders tended to be very extensive. Unsuitable space tended to form islands or a patchwork within a connected suitable space.

WINTER SURVIVAL

Two of the conditions associated with winter were simulated in the laboratory: lack of food and cold temperature (Table 9). A more realistic simulation of winter should include gradual changes in photoperiod, for example, which would permit the spider to prepare for diapause. However, even with the relatively superficial simulation that was employed, more than half of the females and immatures survived. In contrast, few males survived, consistent with observations from nature. Evidently, adult females and immatures, but not adult males, survive the winter in Alpine habitats, since adult females and immatures, but not adult males, were found when the snow melted in early summer.

The repeat of the experiment using non-Alpine spiders (Table 9) is interesting in showing that the capacity to withstand prolonged periods under reduced temperatures and without food is not restricted to Alpine spiders. Each of 3 males, 3 females, and 21 immatures from Whiskey Mountain, maintained and fed under normal laboratory conditions during this same time period, died before the other spiders were removed from the refrigerator. Each of the spiders that survived in the laboratory experiment was provided food and water when removed from the environmental chamber. The 3 males died within one week of the end of the experiment; each female and immature lived at least three weeks before they were preserved.

Most likely, a one year life cycle normally occurs in the field, at least in the Coastal Range and Beach habitats. However, since a relatively short portion of the year is free from snow in the Alpine habitats and since immatures can survive several months without food when exposed to cold temperatures, consideration needs to be given to the possibility that some *P. johnsoni* in Alpine habitats remain immature longer than one year. It is noteworthy that 102 spiders collected in June at Whiskey Mountain as small (body length 6 mm or less) immatures survived in the laboratory until October or longer before preserved or used in the experiment involving refrigeration, and each remained immature.

GENERAL DISCUSSION

Iteroparity — In *P. johnsoni*, as in probably the majority of spiders (Bristowe 1958), iteroparity occurs. That is, eggs are oviposited in successive batches, rather than in a single batch (semelparity). From models of Murphy (1968) and Charnov and Schaffer (1973), iteroparity would be predicted when the risks of complete failure of batches is great and when survival rates of adults are relatively high compared to immature survival rates. For *P. johnsoni*, destruction of eggs by predators, desiccation, and other factors might be a major risk. Also, future studies should look at whether the small immatures are subject to relatively high mortality due to desiccation and the shortage of suitably small prey when

they emerge in the late spring and early summer. Factors such as these might place a positive selection pressure on females that spread their eggs in time among a number of batches. This characteristic could be viewed as "insurance" against environmental risks.

Emlen (1973) suggested that physical limitations might influence the number of eggs per batch in some species. Gravid females of *P. johnsoni* have greatly distended abdomens; and immediately after oviposition, their abdomens are much smaller in size. The number of eggs per batch might be increased by decreased egg size, increased abdomen distension or both. However, smaller eggs would produce smaller spiderlings at hatching, and there might be a great disadvantage for smaller spiderlings related to feeding, dessication, and growth rate (see Lawlor 1976). The advantages related to increased abdomen distension might be countered by disadvantages such as decreased agility, which might lead to increased susceptibility to predation or decreased feeding efficiency.

Decreasing Batch Size and Hatch Proportion — Another characteristic related to oviposition is the decreasing number of fertile eggs in successive batches. There are a number of factors which might favor early batches over later ones for a given female. In the Coastal Range, oviposition begins in the spring, and later batches are oviposited in the summer. Summers are hot and dry, and dessication may be a greater risk in the summer for spiderlings and eggs. Also, small insects probably become less available to the spiderlings as the dry season approaches. Female survival rates also may decrease in the summer. These factors would favor females that invest a greater proportion of their total reproductive effort in the first batch and decreasing proportions in each successive batch, resulting in decreasing number of eggs in later batches.

Absolute batch size will not be discussed here. For an interesting discussion of this subject, see Enders (1976).

Decreasing hatch proportion in successive batches might be simply the result of sperm depletion or loss of sperm or egg viability over time. Another possibility is suggested by the fact that the spiderlings of some species, including *Phidippus regius* (Edwards 1975), feed on infertile eggs before departing the egg sac (Valerio 1974). It is not known whether this occurs in *P. johnsoni*. It would be interesting to investigate the hypothesis that sterile eggs in fertile egg sacs have been selected for as "trophic eggs" (Wilson 1971). Since later batches are oviposited at a time of the year when conditions are probably less favorable for the spiderlings, possibly a greater proportion of sterile eggs are included as a result of selection favoring females that provide increased nourishment per spiderling in the later batches. Provision of sterile eggs, fed upon by the spiderlings, could be viewed as an alternative to provision of more yolk per egg.

Intersexual Size Variation — In *P. johnsoni*, males tend to be smaller than females, which is a very common occurrence in other arthropods and in animals in general. Following Ghiselin's (1974) arguments, it will be proposed that the body size of male *P. johnsoni* is the result of an evolutionary compromise resulting from two types of intermale competition. Competition by "male dispersal" is analogous to a race in which the males that find and mate with the largest number of females within a certain time period are favored. Selection for early maturation by males, accomplished by molting fewer times before maturity and resulting in smaller adult body size is expected. An additional factor is that the benefit (in terms of fitness) for the male is probably greatest for males that mate with newly matured females after cohabitation (Jackson 1976) since these females are the most likely to oviposit fertile eggs and the least likely to mate with

additional males. Males that mature earlier will encounter a greater number of subadult females.

Competition by "male combat" evidently occurs in *P. johnsoni* also (Jackson 1976), and this form of competition favors larger males. When two males encounter the same female, an aggressive interaction ensues and the larger male tends to drive away the smaller and mate with the female. However, selection related to male combat seems not to be sufficient in magnitude to result in males being larger than females.

Various factors probably favor larger size in females. One of these is probably the ability to store food that will be incorporated into eggs. Also there is probably selection for greater longevity related to oviposition over a prolonged period of time. This may select for larger size. For example, larger individuals may be able to store a greater quantity of fat, enabling them to more effectively endure periods of food shortage that may occur during the summer, waiting to oviposit when conditions become favorable. Also, females tend to remain inside their nests with their eggs, and there may be selection favoring endurance with relatively little food during this period. If females defend the eggs from parasites and predators during this time, this might be still another factor favoring larger size.

Intrasexual Size Variation — Great intraspecific variation in size and number of molts between hatching and maturity has been reported for spiders belonging to a wide variety of families (Levy 1970). In some cases, proximate factors such as nutrition and temperature influence the number of instars that occur (Bristowe 1958, Browning 1941, Jones 1941, Juberthie 1954, 1955). In other cases, as in *P. johnsoni*, the number of instars varies even when feeding, temperature, and other factors are held constant. Variable number of preadult instars are known to occur in various insects also (Chapman 1969). Intrasexual variation in the number of instars may be related to factors favoring intrasexual variation in maturity date and size. For females, variation in the maturity date of her offspring might be the result of selection acting on females similar to that discussed in reference to iteroparity. That is, it could be related to insurance against all progeny happening to mature at a time that is unpredictably unfavorable (see Cohen 1966). In the case of males, it was suggested earlier that opposing selection pressures favor larger and smaller adult size (also see Robinson and Robinson 1978). Perhaps natural selection favors the female that produces some optimal mix of male size classes in her progeny.

Difference in Female and Male Longevity — Shorter longevity of males compared to females seems to be a common pattern in animals. Greater susceptibility of males to predators, due to more conspicuous coloration, for example, might be a factor in the field. However, this longevity difference occurs with *P. johnsoni* in the laboratory also. In the laboratory, predation was absent; food was plentiful; and the males and females were kept under identical temperature and light regimes.

Males seem to be adapted to a lifestyle that emphasizes courtship, mating, and searching for females, in conjunction with greater vagility and earlier maturity, at the expense of maintenance functions that serve to prolong survival. Copulation is the male's only investment in the next generation. In contrast, females produce eggs stocked with yolk, oviposit successive batches over a period of several months; and remain at the maternal nest until the spiderlings hatch and disperse. These factors favoring prolonged life of females are not operative on males.

Causes of Interpopulational Variation in Phenology — Response to photoperiod and synchrony of adult mortality are possibly the two major factors responsible for phenology differences in populations of *P. johnsoni*.

During the summer in the Coastal Range (Fig. 9 and 10), adults, especially males, die; eggs hatch; and the next generation begins. In the laboratory, with continual food and constant 24°C temperature, spiders require 6 to 7 months after hatching before reaching maturity; and possibly greater time is required in the field, where temperature and feeding are not as uniform. Perhaps the immature spiders in these populations generally are not able to mature much before the spring mating season. However, the relatively synchronous maturation that occurs in the field suggests that other factors are involved as well, one of which might be photoperiod characteristics.

In the Beach habitats (Fig. 11 and 12), where adults are probably not subject to environmental conditions during the summer that are as severe as those in the Coastal Range, females tend to survive and oviposit through the summer and into the fall. Compared with the Coastal Range, summer mortality of adults seems to be a lesser factor in synchronizing the life cycle. However, there is a mating season in the spring marked by a preponderance of spiders, especially males, maturing at this time; and perhaps this is related to response to photoperiod. The less distinct nature of the mating season in the Beach populations may be due to lesser influence of summer mortality in these populations and perhaps a less sharply tuned response to photoperiod.

At Whiskey Mountain the mating season probably corresponds to the period during which the ground is not covered by snow. Males do not seem to survive the winter in Alpine habitats, and subadults mature soon after the snow melts in early summer. Although the importance of photoperiod is not known, winter mortality alone must be a major factor synchronizing the maturity of males. At Pothole Dome (Fig. 13) males are abundant in early summer, but they become difficult to locate when conditions become increasingly xeric later in the summer. In this case the combination of summer and winter mortality of males would seem to be of major importance in synchronizing the early summer mating season.

Intraspecific phenology differences among populations in different habitats occur in European lycosid spiders (Bonnet 1930, Edgar 1971b). Individuals from populations in the more southern part of some species' ranges mature in a single year; but in more northern populations, most individuals require two years. In New Guinea there is intraspecific variation in the phenology of some Araneidae. More pronounced seasonal trends occur in some populations; less, in others (Robinson *et al.* 1974). Intraspecific differences in life history characteristics have been reported in birds (Baker 1938, Johnston 1954), fish (Schaffer and Elson 1975), crustaceans (Strong 1972), insects (Babcock and Vance 1929), and plants (Clausen *et al.* 1948) also; and in some cases, experimental work has shown variation to be ecotypic. An ecotype is a genetic subunit or variety within a species, adapted to local environmental conditions (Turesson 1922). Future work with *P. johnsoni* should address the question of whether populations vary ecotypically in the manner in which individuals respond to photoperiod and other environmental factors.

Comparative Studies — One of the most powerful tools for investigating evolutionary problems is the comparative method, and several observations from the literature suggest that a comparative study of spider life history strategies would be productive. For example, Gardner (1965) reported that *Phidippus clarus* Keyserling is semelparous. From the arguments presented earlier, it would be predicted that mortality represents a lesser risk for eggs and immatures in this species compared to iteroparous species such as *P. johnsoni*, *P. coccineus*, and *P. regius*. In Kaston's (1970) especially thorough study of the black widow spiders (*Latrodectus*), several intriguing differences in life history characteristics are evident when these spiders are compared to *P. johnsoni* and other spiders.

Latrodectus may begin to oviposit infertile batches followed by additional fertile batches. There is no clear trend for decreasing number of eggs per batch and hatch proportion in successive batches. The number of days between copulation and the first oviposition was highly variable. *Latrodectus* (Theridiidae) are not closely related to the salticids, and there is presently insufficient information available to warrant a discussion of the ultimate causation of these life history differences. Certainly it seems that important differences exist in the life histories of different species of spiders, and our understanding of the evolution of these differences can very likely be clarified by comparative studies.

ACKNOWLEDGEMENTS

Special thanks go to Roy L. Caldwell, Lennell Allen, and Charles E. Griswold for their assistance during all phases of this work. Stephen Jackson's valuable help in Wyoming is gratefully acknowledged. I would like to thank Frank Enders, David Hill, Michael Land, Robert Yamamoto, and Mary Catharine Vick for their comments on the manuscript and Carol Willard for her help with the figures. Evert Schlinger provided valuable discussions. Thanks go to Rubenia Daniels for typing the manuscript. The California Department of Parks and Recreation, the East Bay Regional Park Service, and the National Parks Service are gratefully acknowledged for their assistance. For their assistance in the laboratory and the field, thanks are extended to Ann Edwards, Jim Edwards, Susan Hammamoto, Leslie Johnson, Nancy Knowlton, Michael Land, Virginia Maeroana, Marjorie Reaka, Jim Stewart, Sam Sweet, and especially Pat Daniels, Ken Evans, Mike Hassul, Zuleyma Halpin, and John Matsui.

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SEASONAL ABUNDANCE AND DIVERSITY OF WEB-BUILDING SPIDERS IN RELATION TO HABITAT STRUCTURE ON BARRO COLORADO ISLAND, PANAMA

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ABSTRACT

Web-building spiders were censused by a visual censusing method in tropical forest understory on Barro Colorado Island (BCI), Panama Canal Zone. An overall trend of low numbers of spiders in the late dry season and early wet season (March to May) was seen on all transects. The majority of the species on the transects had wet season distribution patterns. Some species which occurred year-round on the forest transects had wet season distributions on a clearing-edge transect. A shortage of flying insect prey or dessication may have been responsible for the observed distributions.

Species diversity and diversity of web types followed the overall seasonal pattern of spider abundance. The diversities of species and of web types were greatest on the forest transect with the highest diversity of structural supports for spider webs. Web density, however, was greatest on the transect at the edge of a small clearing.

Faunal composition, diversity of web types, and seasonal patterns of distribution of spiders on the BCI transects differed markedly from similar measures derived from censuses taken in a tropical montane habitat in New Guinea. The differences were attributed in part to differences in the habitats and in the evenness of the climate.

INTRODUCTION

Web-building spiders are conspicuous, abundant, and diverse in some tropical forest and forest-edge habitats. The spiders range in size from less than 1 mg to 2 g, construct a wide variety of web types, and may be found in microenvironments ranging from the surface of the leaf litter to forest canopy. They all have in common an insectivorous diet, and, specifically, specializations for capturing airborne insects. The ecology of this group of predators in the humid tropics is poorly known. I report here the results of a year's census of web-building spiders on Barro Colorado Island (BCI) in Panama and illustrate some of the seasonal changes in abundance and diversity of these spiders in the understory of a wet, lowland tropical forest.

The occurrence of measurable seasonal variations in population parameters of plants and animals in tropical forests is now well documented. Fruiting, flowering, and leafing of trees show one to two peaks per year on BCI, though this may vary from species to species (Foster 1973, Smythe 1974b). Peaks of insect abundance can be roughly corre-

lated with certain flowering, fruiting, or leaf-flush peaks (Wolda in press, Fogden 1972, Smythe 1974b, Buskirk and Buskirk 1976). In at least one instance, a cocoa forest in Ghana, population peaks of primary consumer canopy insects were directly correlated with seasonality of host trees (Gibbs and Leston 1970). There is reason to expect that specialized predators, such as web-building spiders, will also show distinct seasonal fluctuations.

Robinson *et al.* (1974) showed that the abundance of web-building spiders in forest-edge and secondary-growth habitats in New Guinea did indeed vary seasonally, though the patterns of variation were different in different species. This study parallels the New Guinea census and affords a direct comparison of spider phenology and diversity in two widely separated tropical localities. Differences between patterns of abundance observed in the two localities give insight into some of the factors that may influence seasonality in the tropics.

METHODS

Visual Censusing of Web-Building Spiders—The visual censusing technique used by Robinson *et al.* (1974) was adopted in this study. The investigator walked along the edge of a line-transect and noted each web spider within the transect. Four transect lines were established, though not all were monitored throughout the entire year. The transects were 1 m wide and 2 m high, extending up from the surface of the leaf litter. Transect 1 was 50 m long, transects 2 to 4 were 100 m long; these were subdivided into units of 10 m for convenience of censusing. The censusing required about 1-2 hours per transect.

Transect 1 was censused four times each month from October 1972 to January 1973, twice in February, April, and May, and once each in March and June to September, 1973. Transect 2 was censused on the same schedule as transect 1 except in April (one census only) and in June (no census). Transect 3 was censused as above until May 1973, with only one census each in April and May. Transect 4 was censused from February to June 1973 with two censuses each in April and May and one each in February, March, and June.

Robinson *et al.* (1974) discussed the advantages and disadvantages of visual censusing for spiders. The method was used by Kajak (1967) to sample spiders in grassland, by Enders (1973) in censuses of the orb-web spider, *Argiope aurantia* Lucas, and by Elton (1973, 1975) to census cryptic insects resting on leaves and twigs in tropical wet forest. Visual censusing is an effective technique when applied to animals with conspicuous artifacts, such as most web spiders. A "search image" is rapidly acquired for webs and for silk in general, as well as for specific shapes of spiders, for retreats of spiders (e.g., curled leaves or pockets of silk on twigs), and for concealing devices of spiders (e.g., stabilimenta in webs). The advantage of visual censusing is that the spiders in the study area remain undisturbed and can be censused repeatedly. As in the New Guinea study, the same observer conducted all the censuses, thus avoiding the problem of varying individual biases.

There are a number of difficulties with the visual censusing method as applied to web spiders. Not all spiders present have intact webs during the census period. Daytime counts select for diurnal species. Some species have fragile and easily broken webs which are less likely to be seen, especially after rainfall or on windy days. Very small spiders and spiders with reduced webs (e.g., single-line webs) are less conspicuous. The same is true for

spiders with small webs inside the leaf litter. Since spiders that build webs inside leaf litter prey for the most part on walking rather than flying insects, they were ignored for the purpose of the census. Low light intensities in the forest understory may reduce visibility considerably. This problem was not encountered on the second-growth transects in New Guinea, but arose on BCI particularly in the rainy season. I did not census on days of heavy rainfall; nonetheless, censusing on overcast days involved much greater searching effort than on clear days.

I evaluate the accuracy of the census figures for the various types of web-building spiders as follows: medium to large web builders (20-2000 mg), small orb-web spiders (5-20 mg), immatures of Uloboridae, *Cyclosa*, *Leucauge*, *Micrathena*, *Nephila*, and *Landana* (less than 5 mg), and the sheetweb building Linyphiidae were all censused accurately. Estimates of other immature orb weavers, all nocturnal species, and small and very small non-orb-web species (excluding linyphiids) are low.

Specimens of most species of web spiders were collected from areas outside the transect lines. Species identification was not possible in all instances. In censusing, I lumped together some species whose webs were difficult to distinguish one from another. Little information is available on the biology of tropical spiders. While censusing, I recorded details of web location, orientation, and structure, the attitude of the spider on or near its web, and its period of activity. Body weights (wet weight) were also obtained for some species. The actual census data are deposited in the library of the Smithsonian Tropical Research Institute.

The Transects—The line-transects are characterized by their location on the island, by the nature of the forest, and by the presence of “edge effects” (Fig. 1). Transect 1 skirted the edge of a small, grassy clearing in the center of the island, isolated from any other large clearings. The vegetation along the edge was dense and there was an abrupt transition from the clearing to the forest. Transects 2 and 3 were along the edge of narrow forest paths (not exceeding 2 m in width). Transect 2 was on flat terrain in 75-year-old forest near the center of the island. There were some understory shrubs and a herbaceous ground cover was generally present. Transect 3 was in old forest skirting the edge of a steep ravine (Lutz watershed). Ground cover and understory shrubs were sparse. Transect 4 was inside the forest, 20 m in from and parallel to transect 2. Understory shrubs and ground cover were present, but less than on transect 2.

In terms of the availability of web supports for spiders (i.e. the density of the vegetation) the transects may be ranked subjectively $1 > 2 > 3 \geq 4$, in order of decreasing desirability. Taking into account the variety of types of web supports (i.e., trees shrubs, lianas, herbs), I rank the transects $2 \geq 1 > 4 > 3$. These rankings are based on a simple vegetation analysis of the transects conducted in February 1973 (Table 1). For this analysis, I selected a 1 m² plot at the beginning of each 10-m section of transect and counted the number of stems or trunks in three size categories: (1) plants less than 50 cm high, (2) 50 to 200 cm, and (3) greater than 200 cm. The number of leaves touching a vertical, weighted thread hung 200 cm above the ground provided a “leaf index” (a mean of three measurements per plot). Low herbaceous plants were most abundant on transect 1, and least so on transect 4. Shrubs less than 2 m high were most abundant on transects 1 and 2, and trees above 2 m were least abundant on transect 3. The leaf index was highest on transect 1 and lowest on transects 3 and 4.

There were conspicuous differences in vegetation between the clearing-edge transect 1 and the forest transects 2, 3 and 4. Transect 2 was separated from the transect 1 clearing

by only 200 m of well-travelled path. As a result, transect 2 was most likely to receive invading "clearing species" and may have also provided enough of an edge habitat to maintain them. Transect 4 was probably most typical of "old forest" on flat terrain, if it is possible to speak of typical vegetation in a forest that is a mosaic of many vegetation types (Bennet 1963, Knight 1975). Transect 3 differed from transect 2 in that it was not near a clearing (separated from the laboratory clearing by at least 600 m of forest), and differed from both 2 and 4 in that it was on highly dissected and steep terrain, providing little foothold for low vegetation.

The four transects differed in their degree of exposure: the clearing-edge transect was most exposed to direct sunlight and rainfall. Changes in the appearance of understory vegetation between dry and rainy seasons were most striking on this transect.

Weather—Temperature and rainfall data for the census period are from Smythe (1974a).

Temperature. During 1973, average yearly temperatures near the forest floor on BCI were ($^{\circ}\text{C}$): maximum 28.0 (26.1-29.4), minimum 22.1 (20.9-23.2). The difference between monthly maximum and minimum air temperatures near the forest floor did not

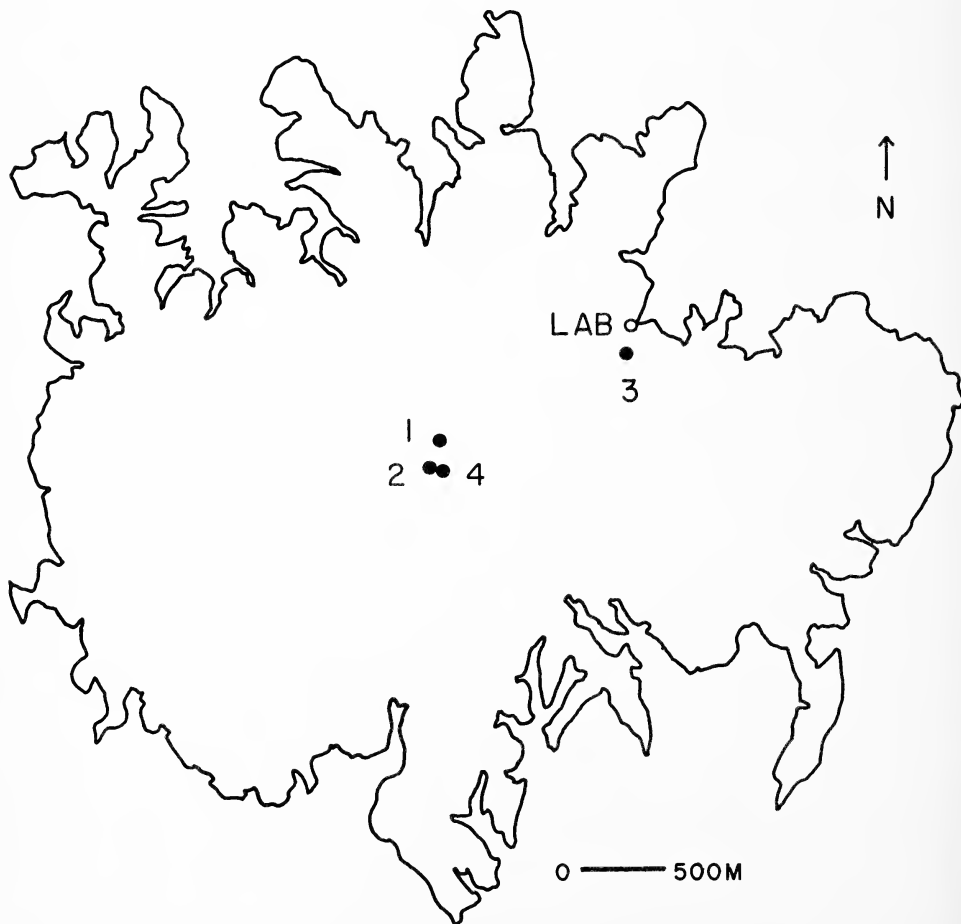


Fig. 1.—Map of Barro Colorado Island, showing the locations of the four transects.

Table 1.—Vegetation analysis of transects 1-4 on BCI, February 1973: average numbers of stems of given height per 1 m² and average leaf index (see text) per 1 m² ± 1 standard deviation.

	Transects			
	No. 1	No. 2	No. 3	No. 4
Stems < 50 cm	50.6 ± 10.7	30.1 ± 16.8	14.0 ± 5.9	10.1 ± 6.8
Stems 50-200 cm	4.2 ± 3.2	5.0 ± 3.7	0.9 ± 1.2	4.1 ± 4.9
Stems > 200 cm	1.8 ± 0.7	3.7 ± 4.2	0.6 ± 0.8	1.5 ± 1.1
Leaf Index	2.1 ± 1.5	1.0 ± 0.5	0.5 ± 0.7	0.4 ± 0.3

exceed 8°C. Air temperatures in the laboratory clearing were slightly higher than in the forest: maximum 31.4 (30.1-33.8), minimum 22.6 (21.8-23.2).

Rainfall. Two distinct seasons are distinguished based on long-term rainfall data: (1) a dry season (December to April), and (2) a rainy season (May to November). Rainfall data for the census period 1972-1973 (Table 2) show a relatively wet December, so that for the census year, the dry season is considered to be January to April. The 1973 dry season was somewhat drier than average. There was a threefold or more difference in the amount of rainfall between wet and dry seasons.

Light. Sunlight may be important for web-building spiders by influencing movements of flying insects. Observations suggest that there are more insects flying in light gaps, in patches of sunlight, and in sunflecks than in shadier areas inside the forest (Lubin, unpublished data). Data on the intensity of sunlight striking the forest understory were not available for BCI.

Table 2.—Average monthly rainfall (in mm) on BCI, Panama Canal Zone, during the census period, October 1972 to September 1973 (Dry season: January 1973-April 1973).

	Rainfall
October 1972	363.2
November	157.5
December	188.0
January 1973	53.3
February	7.6
March	5.1
April	25.4
May	299.7
June	353.1
July	241.3
August	170.2
September	304.8
Total	2,169.2

NATURAL HISTORY

Araneidae—Most spiders of this family construct orb webs. Araneids with reduced webs or no webs (e.g., *Mastophora*) were not encountered on the transects. Descriptions of the ecology and webs of some tropical orb weavers (e.g., *Cyclosa*, *Micrathena*, *Argiope*) can be found in Peters (1953, 1955).

Micrathena species: Spiders of this genus have hard and often spiny abdomens. They are diurnal and sit at the hub during the day. Males are generally very much smaller than

females and were found on webs of their own or near webs of females. As it was difficult to identify the males to species, they were lumped in the census. Species found on BCI are described in Chickering (1961). The mating behavior of *Micrathena* is described by Robinson and Robinson (in press) and aspects of the predatory behavior by Lubin (in prep.).

Micrathena schreibersi (Perty) (female 160 mg, male approx. 10 mg) builds a small, usually vertical, orb web near the ground in forest or forest-edge habitats. Females are aposematically colored red, white, and black. They are easily disturbed by substrate vibrations, reacting by jumping off the web onto the ground or hiding under a leaf.

Micrathena duodecimspinosa (O.P.—Cambridge) (female 20 mg, male approx. 10 mg) constructs a small, vertical, orb web with long frame threads which enable the spider to suspend its web across paths or in gaps between trees. Females may be yellow or white; the yellow color phase is predominant on BCI.

Micrathena horrida (Taczanowski) (female 55 mg) has a small, horizontal or angled web and is most often found in tree buttresses. The brown spider sits at the hub in a cryptic position with all legs folded in toward the body, resembling a piece of leaf or twig.

Micrathena clypeata (Walckenaer) females are flattened dorsoventrally and resemble a bit of dried leaf. One individual was found on transect 1.

Pronous tuberculifer Keyserling (female approx. 10 mg) is a bright red spider which builds a tiny, vertical, orb web at ground level. The web requires very few supporting structures and may catch walking insects as well as insects flying near the ground.

Nephila clavipes L. (female 900 mg), the largest orb weaver on BCI, has been studied in some detail by Robinson and Mirick (1971). The orb web of this species is large (up to 1 m in length) and made of strong, yellowish silk. There is an irregular tangle of threads, the barrier web, on one or both sides of the orb web. Adult *N. clavipes* are often clumped in favorable locations. Kleptoparasites and inquilines are common in webs of adults and subadults. These include the theridiids, *Argyrodes* spp., which have no webs of their own, and *Uloborus* spp. which spin their orb webs within the confines of the barrier web and frame threads of the *Nephila* web (Struhsaker 1969). Adult male *N. clavipes* live as parasites in webs of subadult and adult females. Three categories of *N. clavipes* were distinguished in the census: males, subadult and adult females, and immatures less than 11 mm long.

Leucauge sp. 1 (female, male 39 mg) is a brightly colored orb weaver which builds a horizontal or angled web in forest clearings or in open spaces in forest understory. In these habitats webs were rarely more than 1 m above ground. There is often an irregular barrier web below the orb, with bits of flocculent silk at the points of attachment of the barrier web and the frame threads, making the whole web quite conspicuous. Another slightly smaller species, *Leucauge* sp. 2, was seen once on transect 2.

Cyclosa caroli (Hentz) (female, male 6 mg) constructs a fine-meshed, vertical orb web in shady areas and areas of dense undergrowth. A line of prey remains embedded in silk, the stabilimentum, bisects the orb vertically. The line does not extend across the hub and the elongated spider fits exactly in the gap between the two arms of the stabilimentum. The spider is the same color as the debris, and is virtually indistinguishable from it. The egg sacs are also concealed in the stabilimentum. The stabilimentum of immature *Cyclosa* may have an incomplete spiral or disc at the hub in addition to or instead of the vertical line.

Landana sp. (female 2 mg) is a forest species like *Cyclosa*. Its web is horizontal or angled, with bits of leaves and dirt suspended on a separate thread slightly below the plane of the web. The spider rests at the hub, at one end of the string of debris. Unlike *Cyclosa*, prey remains are not suspended in the stabilimentum.

Mangora pia (Chamberlin and Ivie) (female 20 mg) constructs a very small-meshed, vertical or angled web in forest or at forest-edge. Though primarily diurnal, intact webs were also seen at night.

Eustala spp. (female 23.5 mg). Two or three species of *Eustala* were lumped in the census. All are primarily nocturnal and construct asymmetrical webs with a retreat on a twig or on a tree trunk. The spider sits in the retreat during the day. Although webs are often intact during the day, the spider does not often respond to prey in the web. Individuals are flat dorsoventrally, cyptically colored, and difficult to see at the retreat.

Metazygia sp. (female 20 mg) is another nocturnal species whose web is sometimes left up during the day. The retreat of *Metazygia* is a silken tube on a twig and is quite conspicuous even when the web is absent. Both *Eustala* and *Metazygia* sit on the hub at night.

Eriophora nephiloides (O.P.—Cambridge) (female 400 mg) is a large and at least partly diurnal spider that sits in a curled leaf retreat during the day and on the hub at night. The large, wide-meshed webs are strong and can hold large insects (e.g., large scarab beetles and sphyngid moths). The spider attacks most prey by wrapping, and is capable of throwing silk onto large prey from a distance.

Edricus crassicaudus (Keyserling) (female approx. 30 mg) was found only on transect 2. Webs are vertical and low in the vegetation. A white, flocculent, linear stabilimentum is sometimes present below the hub. The spider is diurnal and sits at the hub facing head down. Two color phases were seen: shiny black and deep red. The spider has a large and striking anal tubercle. When disturbed, it runs off the web and sits on a leaf, folding its legs toward the body so that it resembles wet fecal material.

Araneus (Alpaida) tuonabo (Chamberlin and Ivie) (female 10 mg) builds a small vertical or angled, diurnal, orb web with long support threads. Webs are built across paths and small openings in the forest.

Araneus sp. (close to *sinuoscapus*) (female 90 mg) is mainly a forest-clearing species. It was found on one occasion each on transects 1 and 3. The spider sits in a rolled-up leaf retreat during the day and on the web at night.

Spilasma sp. This unusual araneid builds a conical silken retreat at the center of a tent-shaped, small-meshed web. The webs of two South American species were described by Simon (1896) and Quintero (1974). The retreat is covered with bits of dirt and lichen and has a hinged flap which the spider pulls in when disturbed. Egg sacs are placed in the retreat and the young remain in the retreat with the mother for several days. One individual was found on transect 2.

Argiope argentata (Fabricius) (female 500 mg) is a forest-edge and clearing species. I found it only on transect 1. Many aspects of the behavior and ecology of this spider are described in Robinson (1969), Robinson and Robinson (1970), and Robinson and Olazarri (1971).

Other Araneidae. Five species of orb-web spiders which could not be identified to genus, and were not collected, occurred rarely on the transects.

Uloboridae—Many spiders in this family construct hackled-band orb webs in which the sticky spiral of the araneid orb web is replaced by a cribellar silk spiral. The species were easily distinguished by the form of the web and the egg sac.

Uloborus sp. 1 (female 10 mg) is an elongate, stick-mimicking spider which rests on its horizontal orb web during the day in a cryptic position with legs I and II extended forward and Legs IV extended backwards. The web often has a linear stabilimentum of whitish silk.

Uloborus republicanus (Simon) (female 20 mg) is a colonial species, though solitary individuals were found occasionally. Colonies are located near the ground, in slightly open spots in the understory. They may contain several hundred individuals and persist for as long as a year (unpublished observations). Females and immatures construct their own orb webs within the framework of the colony; subadult and adult males apparently do not build webs. One large colony persisted on transect 2 from October to December.

Uloborus sp. 3 (female 9 mg). Orb webs of this species are asymmetrical and often clumped. A portion of the web is attached to a leaf or other shelter under which the spider retreats when disturbed. As in the colonial species, males are often found near or in webs of females. This species prefers open habitats.

Miagrammopes simus (Chamberlin and Ivie) constructs a single-line snare. A portion of the line is covered with hackled silk which traps the prey. The web and prey capture behavior are described by Lubin *et al.* (in press). Individuals were found rarely on transects 1 and 2.

Theridiidae

Argyrodes spp. (approx. 3 mg). Two species of *Argyrodes* kleptoparasites or inquilines were found in webs of *Nephila clavipes*. These spiders do not build webs of their own, but steal prey from the host spider.

Argyrodes sp. (close to *longissimus*) sits on a single thread which does not appear to be sticky. The manner in which this spider captures prey is not known; I have found individuals feeding on other spiders.

Tidarren haemorrhoidale (Bertkau) (female 44 mg). This may include one or two other species of theridiid that construct irregular-mesh tent webs. The web is a "knockdown trap" for flying insects: the insects encounter the vertical threads of the barrier web and are knocked down or drop onto the tent-shaped sheet. The spider sits in a curled-leaf retreat at the apex of the tent. The web is functionally similar to that of *Achaearanea tessellata*, described by Eberhard (1972), and like that of *A. tessellata* it apparently does not contain sticky silk.

Theridiid sp. 2 (approx. 1 mg) includes perhaps several species of tiny spiders that construct irregular-mesh spherical webs. It is not known if the webs contain sticky silk. The spider sits in the center of the web, sometimes concealed under a piece of debris. Webs were generally found in tree crotches or near tree trunks.

Synotaxus ecuadorensis Exline (female 3 mg) is a theridiid which constructs a planar or 2-dimensional, wide-meshed web with an almost radial structure. Parallel, sticky silk radii extend down from a retreat under a leaf and are connected by horizontal threads which are not sticky. Eberhard (in press) has described the structure and web-building behavior of a species from Colombia.

Episinus sp. (female 3 mg) also constructs a planar, open-meshed web below a leaf. The web is smaller and less regular in structure than that of *Synotaxus*.

Other Web-Building Spiders

Theridiosoma sp. (Theridiosomatidae) (less than 1 mg) are probably quite common near the ground in the forest understory, but their tiny webs are fragile and difficult to

see. Orb webs of *Theridiosoma* lack the structured hub of araneid webs. These spiders were recorded on transects 2 and 4.

Scytodid (female 7 mg). This spider constructs a rather dense, irregular-mesh, vertical web under leaves. The spider rests under a leaf or on the surface of the web. The web does not appear to be sticky, and may simply serve to alert this agile spider to the presence of an insect on its surface.

Linyphiid (female, male 4 mg). Linyphiids build small, horizontal, sheet webs with a vertical snare above the sheet. The spider rests upside down under the sheet.

Pholcid (approx. 30 mg). These long-legged spiders rest upside down under a loose-mesh sheet web, generally located near ground level. There is usually a retreat under the leaf litter, under a log, or in a crevice. Probably several species were lumped together.

Dinopis longipes Cambridge (Dinopidae), the ogre-faced spider, sits on an A-frame suspension web, facing a vertical surface and holding a square of hackled silk between its first two pairs of legs. It throws this net over insects that walk under it (Robinson and Robinson 1971) and probably specializes in walking rather than flying insects. It was seen once on transect 2.

RESULTS AND DISCUSSION

Seasonality of Web Spiders—The overall seasonal trends in abundance of web-building spiders (Fig. 2) show (1) a sharp decrease in abundance of spiders in the dry season, continuing into early wet season, and (2) two population peaks in the late wet to early dry season and in mid wet season. On transects 2, 3, and 4 there was a smaller increase in total numbers after the first rains at the end of the dry season (April), followed by a decrease at the beginning of the wet season.

Most species of web-building spiders on transect 1 occurred in low numbers or disappeared entirely during the dry season (Fig. 2, Table 3). Only *Metazygia* sp. occurred essentially year-round on transect 1. Transect 2, however, had an equal number of species with essentially year-round and wet season distributions. *Mangora pia*, *Cyclosa caroli*, *Synotaxus ecuadorensis*, and the pholcid all occurred primarily during the wet season on transect 1 and year-round on transect 2. These species must be considered primarily shade-loving, forest species for which the clearing edge is unsuitable during the dry season. Likewise, *Landana* sp. had a wet season distribution on transect 2, but occurred throughout the dry season on the forest transect number 4. It did not occur at all on the clearing-edge transect number 1.

Adults and immatures of some species had different patterns of distribution (Table 3). Immature spiders of *Leucauge* sp. 1 and of *Nephila clavipes* had broader seasonal distributions than did the adults. Immatures of both species occurred nearly year-round (absent or in low density during late dry and early wet seasons), while the adults had much more restricted distributions. Adult *Leucauge* peaked in the wet season and adult *N. clavipes* had two disjunct peaks in mid wet and early dry seasons. Immature *Leucauge* were present on transects 1 and 2 respectively on 74.1 and 86.2% of the censuses, while adults were present on only 40.7 and 24.1% respectively. On transect 1, immature *N. clavipes* occurred on 85.2% and adults on 33.3% of the censuses.

Immature Araneidae (orb-web spiders) in general were present year-round on transects 1 and 2. They comprised 30-80% of the total number of Araneidae present on any census (Figure 3). The year-round occurrence of immatures may be attributed to (1) the year-

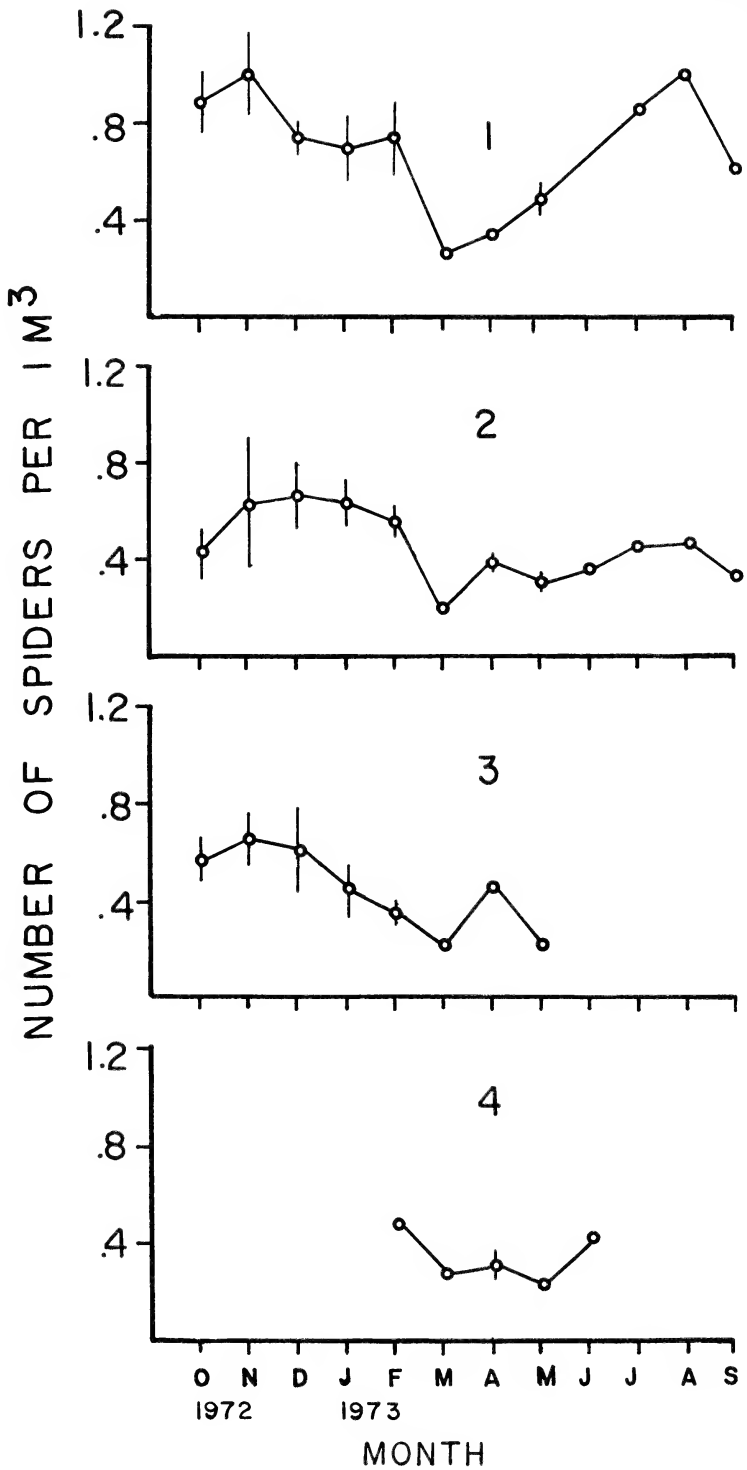


Fig. 2.—Average number of web-building spiders per month on four transects. Vertical lines are one standard deviation.

Table 3.—Occurrence of web-building spiders on transects 1-4. Shown are the transect numbers on which each species was found during the census period, and the total number of individuals recorded (all transects combined).

SPECIES	MONTHS												Total No.
	O	N	D	J	F	M	A	M	J	J	A	S	
<i>Micrathena schreibersi</i>	1	1	12	1					2		1	12	13
<i>M. duodecimspinosa</i>	1	123	123	13	2								27
<i>M. horrida</i>		1	123	13			2					1	19
<i>Micrathena</i> males	123	123	123	1		2	4	2		12		1	73
<i>Pronous tuberculifer</i>		3	23	123	124	2		12	2	2	12	12	35
<i>Nephila clavipes</i>													
adults, subadults			1	12	12	1				12	1		21
immatures	12	1	12	12	12		13	12		2		12	81
males			1	1	12					1	1		20
<i>Leucauge</i> sp. 1, adults		123	123	13	1			2		12	1		53
immatures	123	123	123	123	123	1	123	24		2	12		415
<i>Cyclosa caroli</i>	123	123	123	123	1234	24	234	1234	2	2	1	12	464
<i>Landana</i> sp. 1	23	23	23	23	24	24	4	4	4	2	2	2	112
<i>Mangora pia</i>	12	123	123	123	12	24	2	2	24	12	12	12	96
<i>Eustala</i> sp.	123	12	123	3	13			12		2	12	2	48
<i>Metazygia</i> sp.	123	12	123	123	1234	1	123	1234	2	12	1	2	167
<i>Araneus tuonabo</i>	123	123	123	12	23	4		2		12	12	12	105
<i>Eriophora nephiloides</i>			1	23	123	1	4	12		1			14
<i>Uloborus</i> sp. 1	123	123	123	2	234	23	24	234	2	2	2	2	352
<i>Uloborus</i> sp. 3	123	123	123	123	1234	124	1234	3	4	12	12	12	679
<i>Argyrodus</i> spp. inquilines	1			12	12	1				2	1		42
<i>A. longissimus</i>	3	123		12			2				2		21
<i>Tidarren haemorrhoidale</i>	123	123	123	123	123	134	1234	1234	4		2	2	244
<i>Theridid</i> sp. 2	123	123	123	123	1234	1234	1234	1234	24	12	2	2	1914
<i>Synotaxus ecuadorensis</i>	123	123	123	23	234	3	2	12	24		2	12	70
<i>Episinus</i> sp.	23	123	2	23	2			23	2	2	12	2	28
<i>Scytodid</i>			23	23	1234	124	234	24	2	12	2		121
<i>Linyphiid</i>	123	23	23	23	3	23	23	13		2	1		70
<i>Pholcid</i>	123	123	123	123	1234	234	234	24	2	12		2	384

round emergence of immatures coupled with complete overlap of generations and/or (2) the occurrence of long development periods of young, spanning seasons which are unfavorable for adults. *Cyclosa* sp. may be typical of a spider with the first reproductive strategy. Adults and immatures were present year-round on transect 2 and it is probable that reproduction occurred throughout the year. *Nephila clavipes* may exemplify the second strategy of long development periods of immatures coupled with pronounced adult seasonality. Adult *N. clavipes* were absent from transect 1 during April-May and September-November. Immatures were present during these periods and may have been derived from egg clutches laid in February-March and July-August respectively. Another possibility is that adult *N. clavipes* are, in fact, present at very low population densities during the periods of absence from transect 1 and that offspring produced during these periods migrated into the census area. The census data suggest that immigration onto transect 1 did occur during October and November; numbers of immatures in successive weeks during this period were 8, 9, 2, 2, 1, 3, 1, and 2.

It is not immediately apparent why adults should be more restricted seasonally than immatures, as is the case in *N. clavipes* and *Leucauge* sp. 1. The negative correlation found between body size and rate of water loss in spiders (Anderson 1974) would lead one to expect that large spiders (adults) could better withstand the dry season than small spiders (immatures). Janzen and Schoener (1968) found that both small insects and very large insects seemed to drop out as one moved from wetter to drier sites in Costa Rica.

Food may be an important limiting factor at certain times of year. Data from light-traps on BCI suggest that small- and medium-size flying insects (up to 15 mm body length) are least abundant during the periods of September-November and February-April, corresponding to late rainy season and late dry season respectively (Smythe 1974b). The dry season decrease corresponds to a period of low spider populations on the transect lines. The wet season decrease corresponds roughly with the disappearance of certain species, e.g., adult female and male *N. clavipes*, *Pronous tuberculifer*, and the scytodid.

There were no species with strictly dry season distributions on any of the transects, although the araneid *P. tuberculifer* and *N. clavipes* adults, and the scytodid and linyphiid, had both wet and dry season population peaks. The absence of these species during the late wet season may be related to food supply as suggested above, or to other factors. *Pronous*, for example, is a small orb weaver which places its web in open spots very near the ground; such a web may be easily damaged by heavy rains.

Web Type and Seasonality—Seasonal abundance patterns correlate broadly with web type. Webs are divided here into two- and three-dimensional structures. Specialized webs form a third, nonuniform category which includes the single-line snare of *Miagrammopes*, the throwing net of *Dinopis*, and the kleptoparasites, *Argyrodes* spp. which have no web of their own but steal prey from the host web. The orb-web species include all the Araneidae, *Theridiosoma*, and the cribellate orb weavers of the genus *Uloborus*. Two-dimensional, nonorb webs (planar webs) are those of the theridiids *Synotaxus* and *Episinus*, and the scytodid. Space webs include those of the theridiids *Tidarren haemorroidale* and theridiid sp. 2; the sheetweb builders are the linyphiid and the pholcid. These groups are not uniform in size or composition: the orb weavers include many species, while the other categories have relatively few species. Furthermore, there is probably greater similarity in web structure and function among the orb weavers than among the species grouped in other categories.

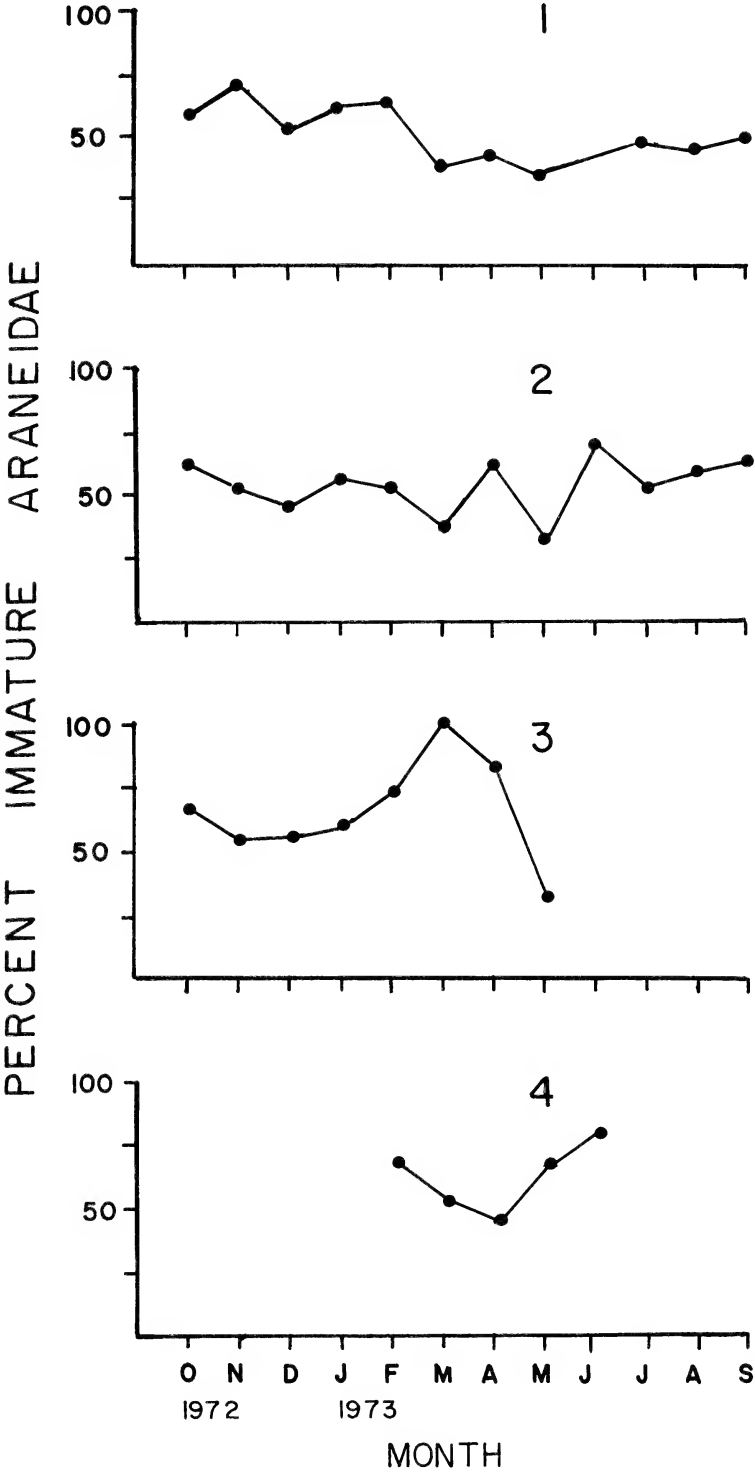


Fig. 3.—Percent of immature Araneidae occurring on four transects, expressed as percent of the total number of Araneidae.

In Fig. 4, I compare the relative abundance of the different web types on transects 1 and 2 in November and April, during late wet and late dry seasons respectively. Orb-web species decreased in relative abundance in April on both transects and, concomitantly, space webs increased in importance. Planar webs and sheet webs disappeared from transect 1 in the late dry season, and increased in relative abundance on transect 2.

Most orb-web spiders rest at the hub of the orb during the day and are susceptible to heating and desiccation. Larger orb weavers, such as *N. clavipes*, exhibit behavioral thermoregulation when exposed to direct sunlight (Robinson and Robinson 1974b). Small orb weavers, however, would be more prone to desiccation due to a greater surface/volume ratio. Webs of orb weavers are generally fragile (with the exception of those of *Nephila*) and may be easily damaged or destroyed by falling leaves and branches.

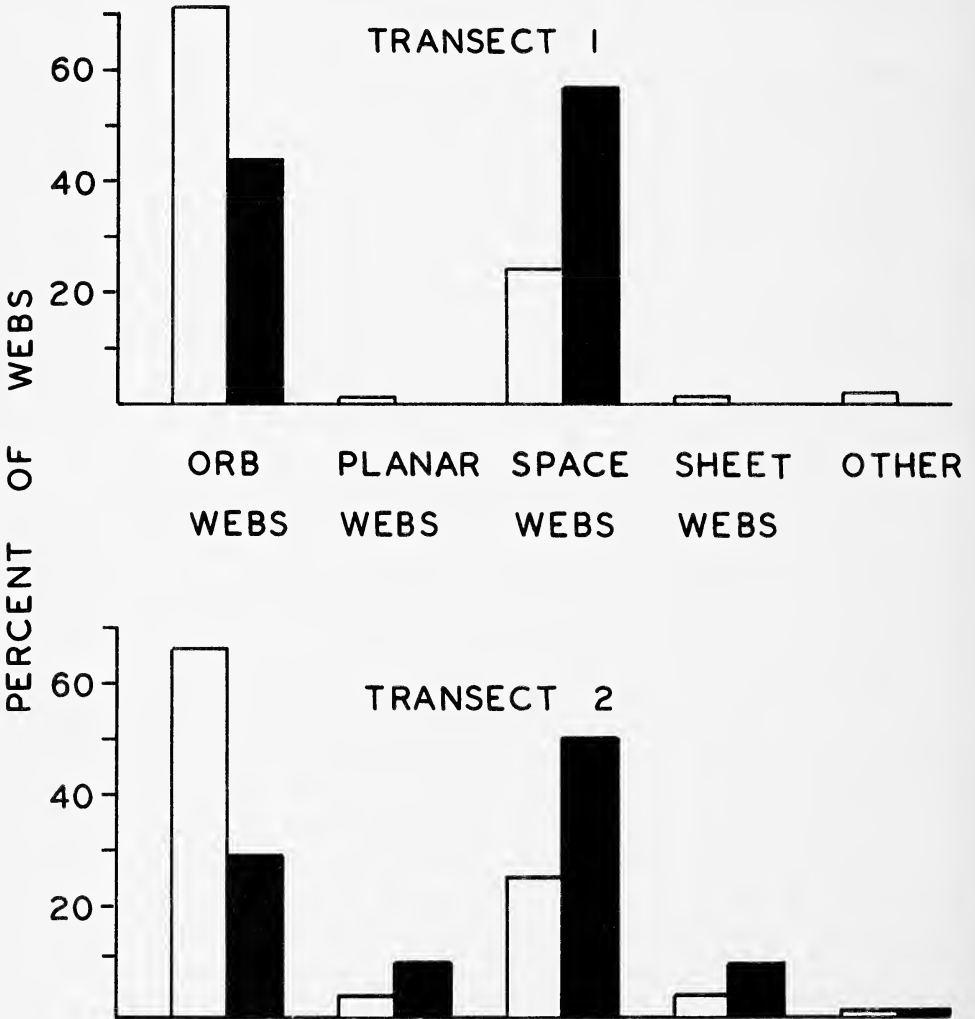


Fig. 4.—Percent of occurrence of different web types on transects 1 and 2 in November and April, expressed as percentages of the total number of webs found on the transects during these months. In November there were 350 webs on transect 1 and 413 on transect 2. In April there were 23 webs on transect 1 and 121 on transect 2.

Dust and pollen may coat the viscid spiral of araneid webs and reduce their effectiveness. These factors may be partly responsible for the decrease in abundance of orb webs during the late dry season. In fact, the decrease in total abundance of web-building spiders during the late dry season was due almost entirely to the drop in numbers of orb-web species.

The argument presented above does not apply to planar, nonorb species or to nocturnal orb weavers. *Synotaxus* and *Episinus* both rest under leaves during the day and are most active at night; the scytodid web is durable and nonsticky and the spider sits in a silk retreat under a leaf. Nocturnal araneids, as well as the diurnal *Spilasma*, sit in retreats during the day. All of these species are less exposed to the dry seasons' adverse conditions.

If flying insects are in short supply during the late dry season, as suggested earlier, then seasonal changes in the distribution of web types may be related to food supply. Most orb weavers renew their webs daily. The actual cost of web construction is relatively small, perhaps as little as 1% of the total energy intake, assuming a cost of 1.1 cal per 0.1 mg web (Peakall and Witt 1976, Prestwich 1977) and approximately 80 cal of food per day assimilated by a 1-g spider (Robinson and Robinson 1970). Nonetheless, in order to renew the web daily, orb weavers need a constant and predictable food supply which may not be available during the late dry season. The cost of web building for an orb weaver may remain constant even during periods of food shortage. *Araneus diadematus*, for example, builds webs of more-or-less constant size even after a week of food deprivation (Witt *et al.* 1968). Space-web and sheet-web spiders, by comparison, renew their webs infrequently and therefore do not have the daily energy demand of the orb weaver. *Filistata hibernalis*, a spider with a durable, nonrenewed, sheet web, reduced its metabolic rate by about 40% during starvation and survived for extended periods (Anderson, 1974). Comparable tests with orb weavers would be worth doing.

Species Diversity, Seasonality, and Habitat Structure—On the basis of the total numbers of species found throughout the census, the transects are ranked in order of descending numbers 2>1>3>4 (Table 4). This ranking is consistent with earlier impressions of vegetation structure and availability of web supports (Methods, p. 32). Transect 2 had the largest number of web-supporting structures, and both transects 1 and 2

Table 4.—Number of species of web-building spiders encountered on transects 1-4: yearly totals, average numbers per census, and range. Averages \pm 1 standard deviation are shown for three periods of high and low spider densities (transects 1 and 2 only): High 1 = October-February, Low = March-June, High 2 = July-September.

	Transects			
	No. 1	No. 2	No. 3	No. 4
Total	31	36	25	17
Average per census	11.3 \pm 2.6	14.7 \pm 3.1	11.05 \pm 2.8	9.0 \pm 1.7
Range	5-16	9-20	6-15	6-11
High 1	11.8 \pm 2.4	14.8 \pm 3.3		
Low	8.25 \pm 2.6	13.0 \pm 1.9		
High 2	11.75 \pm 2.4	18.3 \pm 0.6		

Transect 1: High 1 vs. Low, $t = 5.3115$, $p < 0.001$
 High 2 vs. Low, $t = 2.6205$, $0.02 < p < 0.05$
 Transect 2: High 1 vs. Low, $t = 2.4340$, $0.02 < p < 0.05$
 High 2 vs. Low, $t = 8.0643$, $p < 0.001$

showed a more pronounced "forest-edge effect," with increased structural diversity at the ecotone, than did transects 3 and 4.

The numbers of species present on the transects were high during periods of high spider density and low during periods of low spider density (Table 4). During the latter period (March through June) transects 1 and 2 had significantly fewer species than during the two high-density periods. The high- and low-density periods, and therefore high- and low-diversity periods, correspond only roughly to wet and dry seasons based on rainfall data. In fact, after dividing the census period into wet and dry seasons (October-December, January-April, and May-September), I found no significant differences in species diversity between these seasons. Since the interactions between climate and the life histories of spiders are undoubtedly complex, one would not expect either abundance or diversity to correlate directly with season as defined solely by climatic data. This was also the case in temperate-zone wandering spiders (Uetz 1975) and in tropical montane rain-forest insects (Buskirk and Buskirk 1976).

Shannon-Weaver diversity indices (Pielou 1966) were calculated using the yearly totals of all species (Table 5). The index of diversity (\bar{H}) is greatest on transect 2, and considerably higher on both 1 and 2 by comparison with transect 3. This is apparently a function of both more species and a more equitable distribution of abundances (E) among the species. This supports the view that species diversity of web spiders is influenced to a large extent by structural diversity of the habitat.

The Shannon-Weaver index of diversity is valid only when sample sizes are large, and the total number of species is known (Pielou 1966). The species discovery curves for the four transects (Figure 5) show that this is approximately true for transects 2-4, but not the case on transect 1, where the curve shows no sign of leveling. These curves also suggest that in order to sample rare species of web-building spiders in a tropical wet forest habitat, one needs a very large area indeed. The shape of these curves is typical of species discovery curves of many groups of tropical organisms (Janzen 1973).

The number of species encountered often varied considerably from one census to the next; for example, transect 1 had 9, 15, 10, and 10 species on four successive censuses in January 1973. Such differences are to be expected if many species occur in low densities and/or for short durations. Although it is not possible with these data to separate these two factors, they undoubtedly both contribute to species rareness.

Table 5.—Species diversity of spiders on three transects: Shannon-Weaver index (\bar{H}), maximum diversity (\bar{H}_{\max}), and equitability (E) indices (Pielou 1966) based on yearly totals of species on transects 1-3.

Diversity Index	Transects		
	No. 1	No. 2	No. 3
\bar{H}	3.568	3.717	2.518
\bar{H}_{\max}	4.954	5.170	4.644
E	0.72	0.72	0.54

The majority of the species of web-building spiders were recorded at least once on all transects. Over the entire census year, transects 1 and 2 shared 93% of the species, transects 2 and 3 shared 83% and transects 1 and 3 shared 65%. During a period of high spider abundance (November) the transects had more species in common than during a period of low abundance (February-March) (Table 6). During the latter period, many species disappeared selectively from one transect, but not from another.

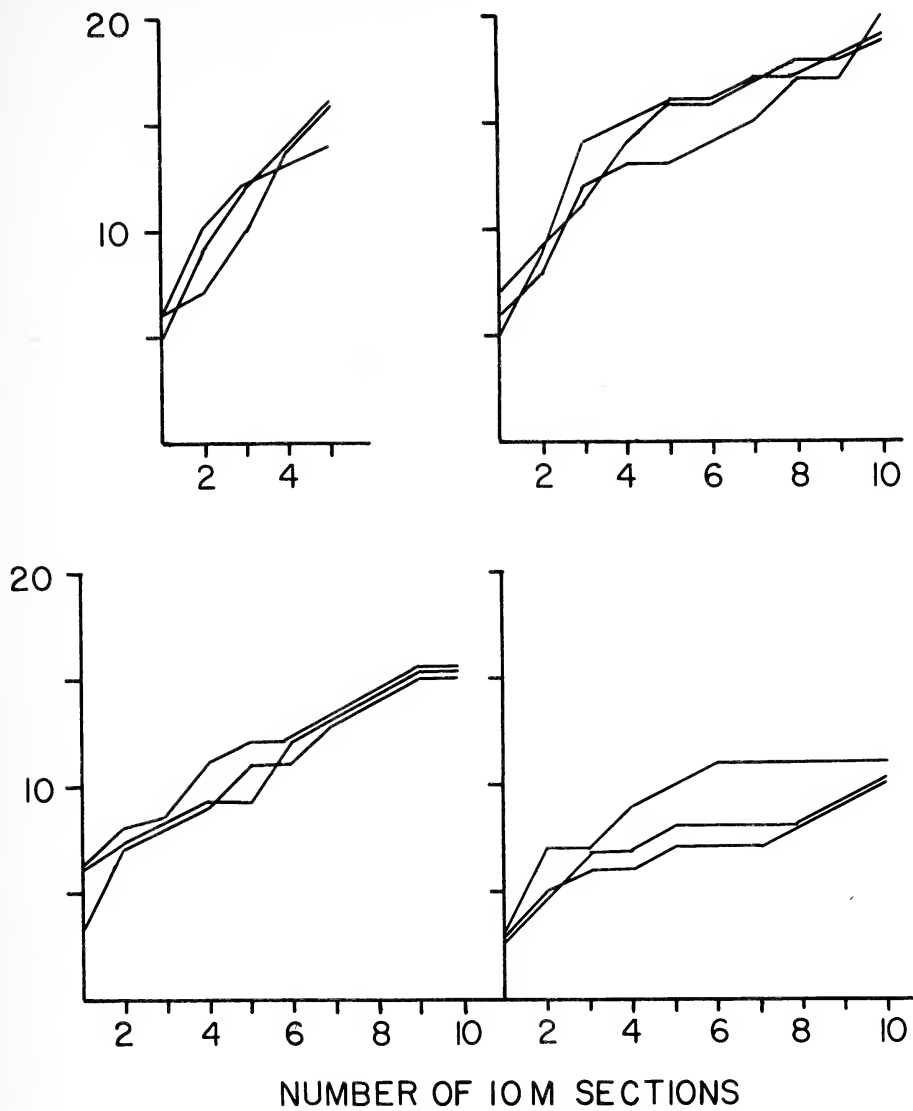


Fig. 5.—Species discovery curves: cumulative numbers of species encountered on successive 10 m sections along transects 1-4. Curves are shown for three dates with the highest numbers of species: transect 1—20 Nov., 25 Dec., 15 Jan.; transect 2—27 Nov., 12 Dec., 25 Dec.; transect 3—13 Nov., 4 Dec., 12 Dec.; transect 4—27 Feb., 23 Mar., 8 Apr.

Coefficients of similarity between the transects were lower in February-March than in November (Table 6). These differences were not statistically significant, with the exception of transects 1 and 2 ($t=3.29$, $0.01 < p < 0.02$). The coefficient of similarity takes into account the abundances of species in common, and thus gives greater weight to the numerically dominant species (Kershaw 1964). Most similar were transects 1 and 2 during November, and the two forest transects, 2 and 3, in both November and February-March. The similarity between the wet season faunas of transects 1 and 2 may be related to (1) the high overall abundance of spiders and greater possibility of movement of spiders

Table 6.—Percent of species overlap on transects 1, 2, and 3 (Number of species in common \times 100/Total number of species), and coefficients of similarity, $C=2w/a+b$, where a and b are the numbers of individuals of all species found on the two transects, and w is the sum of the lesser values of the species common to the two transects (Kershaw 1964:165). Shown are percent species overlap for four censuses combined in November and four in February and March; coefficients of similarity are means of the four censuses in each period \pm 1 standard deviation.

Transects	November		February-March	
	% overlap	C	% overlap	C
1 and 2	69.6	0.51 ± 0.06	58.3	0.34 ± 0.11
1 and 3	62.5	0.39 ± 0.01	55.0	0.25 ± 0.004
2 and 3	68.2	0.47 ± 0.07	54.2	0.47 ± 0.01

between the two transects, and (2) a greater similarity in habitat structure during the wet season, namely the presence of a well-developed herbaceous layer on both transects.

BCI and New Guinea: A Comparison—Populations of web-building spiders at Wau, New Guinea, and on BCI reflect the favorable climatic conditions of moist tropical habitats in that there is no season that is entirely unsuitable for spiders (Robinson *et al.* 1974). Fluctuations in total population size were of the same order of magnitude and did not exceed threefold at either locality. Adults and immatures occurred year-round and even the most seasonal species (e.g., *Nephila clavipes* on BCI) had overlapping generations. The implications of year-round occurrence and overlapping generations are discussed by Robinson *et al.* (1974) in terms of allowing a large number of biotic interactions or links between a given species and other species in its environment, and thereby contributing to greater species diversity.

Both census localities have distinct wet and dry seasons, but the dry season is very much more pronounced on BCI. Although total rainfall over the census period was similar at the two localities, rainfall was distributed more evenly over the year at Wau than on BCI. The driest month at Wau (August) had 28 mm of rain, while on BCI the driest month (March) had only 5 mm. Total rainfall during the four driest months at Wau was 279 mm (June-July, August-September) and only 91 mm on BCI. Furthermore, the driest month at Wau was preceded by a relatively wet month with over 100 mm of rain.

Daily temperature fluctuations were greater at Wau (10-12°C) at about 1150 m altitude than at BCI (7-10°C in the clearing and 4-8°C in the forest) at an altitude of 50-100 m. The differences between daily minimum and maximum temperatures were greatest in both places at the end of the dry season or early wet season.

On all of the Wau transects there was a preponderance of species with abundance peaks during the drier months, whereas on the BCI transects there were virtually no web-building species that peaked in abundance during the dry season. Most species on the BCI transects had essentially wet season distributions, and some had population peaks corresponding to mid wet season and late wet or early dry seasons. I suggest that the dry season is a critical period on BCI, and that population sizes are limited during this period due to food shortage and/or desiccation. At Wau, there is probably sufficient moisture throughout the dry season to permit continued activity and reproduction in web spiders. Insect-trap data suggest that insect prey are available year-round (Robinson and Robinson 1973, Lubin unpubl.).

A major difference between the two censuses is in the nature of the transects. The Wau transects were all in open, second-growth habitats along forest edge or along the edge of overgrown coffee plantation. Unlike the BCI clearing transect (no. 1), which was quite isolated, they were connected with extensive areas of roadside and second-growth habitat. This difference is reflected in the distribution of web types at the two localities. Thirteen species of non-orb-web builders were found on all BCI transects combined, or 37% of all species, while only 22% of all species on the Wau transects were non-orb-web builders. There were 35 species on all of the BCI transects over the period of the census and only 27 on the Wau transects. In general, there was a greater diversity of web types and more three-dimensional webs on the BCI transects than at Wau. I attribute this difference to the more structured habitat on the BCI transects which provides supports for different web types.

Differences between the physical nature of the Wau and BCI transect lines are also reflected in the actual species composition. *Gasteracantha*, *Argiope*, *Leucauge*, and *Tetragnatha* are all early second-growth, forest-edge genera; on the Wau transects there were four species of *Argiope*, and two of *Gasteracantha*. *Leucauge* and *Tetragnatha* were abundant. On the BCI census lines only *Leucauge* sp. 1, *Nephila clavipes*, and *Argiope argentata* can be considered true clearing species. *Argiope* was rare and occurred only on transect 1 (the clearing transect), and *Nephila* was found in low densities on transects 1 and 2, but more commonly on transect 1. *Leucauge* seems to be a truly versatile spider and invaded the forest paths with great success, but nonetheless was most abundant along the clearing edge. A substantial number of species found on the BCI transects are entirely or primarily forest-dwelling species. These are *Micrathena schreibersi*, *M. clypeata*, *Pronous tuberculifer*, *Landana* sp., *Eriophora nephiloides*, *Spilasma* sp., *Miagrammopes simus*, and *Synotaxus ecuadorensis*.

Although clearings and forest-edge habitats may be less favorable for some species, these habitats tend to support higher densities of spiders than do inside-forest habitats. On BCI the highest densities of web-building spiders were recorded on transect 1, with a maximum of 1.1 spiders per 1 m^3 in November. Maximum spider densities on the forest transects on BCI were slightly lower: 0.6 spiders per 1 m^3 on transects 2 and 3, and 0.4 on transect 4. Maximum population densities on the Wau transects were of similar magnitude to that of BCI transect 1, approximately 0.75, 1.2, and 1.3 spiders per 1 m^3 on the three transects (assuming each transect is $2 \times 2 \times 100 = 400\text{ m}^3$). Robinson and Robinson (1974a) estimated a higher density yet (2.9 spiders per 1 m^3) of diurnal web builders inside a coffee plantation in Wau in July 1974.

There is evidence suggesting that insect abundance and diversity are higher in mid-elevation, tropical montane rain forest than in comparable lowland forest (Janzen 1973, Buskirk and Buskirk 1976). The difficulty is in finding comparable habitats at different altitudes. The Wau and BCI censuses indicate less fluctuating and perhaps more evenly distributed populations of web-building spiders in the montane habitat, but not necessarily larger or more diverse. The differences are complicated by the fact that the Wau census was in second-growth habitat and the BCI census in forest understory. The July, 1974, daytime census (Robinson and Robinson 1974a) in a coffee plantation, which is closer in vegetation structure to a forest understory, yielded approximately 18 species of web spiders, a figure comparable to the highest species counts on the BCI transect 2. It also yielded higher population estimates than any of the BCI transects. From this, one can only conclude that generalizations about arthropod abundance and diversity in montane versus lowland tropical habitats may be premature.

ACKNOWLEDGMENTS

This study was supported by a Smithsonian Tropical Research Institute postdoctoral fellowship. I thank M. H. Robinson, S. E. Reichert, and C. D. Dondale for reviewing the manuscript, and H. W. Levi for identifying many of the specimens.

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ECOLOGY OF THE WOLF SPIDER, *LYCOSA* *CAROLINENSIS* WALCKENAER (ARANEAE, LYCOSIDAE) IN A DESERT COMMUNITY

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ABSTRACT

Various aspects of the ecology of *Lycosa carolinensis* Walckenaer have been investigated in a Lower Sonoran Desert community, including surface activities, seasonal activities, and burrow construction. The average home range is 1.1 m² and parts of the home range boundaries are proposed to be limited by changes in topographical relief.

Adults and immatures are inactive from November through February. Immatures reach their highest percentage during the months of March and October. The peak percentage of females and males occur in June and July, respectively. Females have two peaks of egg sac carrying in late July and late August and can possibly have two broods of spiderlings per year. It is thought that females do not reproduce until the third summer and possibly live one year or more. Males also mature in the third summer, but die the year they reproduce.

The burrows occupied by *L. carolinensis* serve as a retreat from heat, desiccation, and some predators. The burrows are randomly distributed with respect to each other but uniformly distributed with respect to shrubs. Most of the burrows have turrets (87%), which probably function as an "early warning system." In the laboratory, 72% of third, fourth, and fifth instar spiderlings construct burrows which they later abandon, giving rise to the possibility that the spider can possess at least two burrows during a lifetime.

INTRODUCTION

In desert regions of North America, only three general studies of spiders have been made (Fautin 1946, Chew 1961, Gertsch and Riechert 1976). Fautin treated spider ecology of communities in the northern desert shrub biome which is dominated by sagebrush, *Artemisia*. Gertsch and Reichert studied the spatial and temporal partitioning of desert spiders in the Chihuahuan Desert of south-central New Mexico. Their study area is characterized by a lava bed, mixed grassland, and rangeland. Chew dealt with the spider ecology in hot southwestern deserts, much like the present study, in an area dominated by creosote bush, *Larrea*. Chew's study only included spiders of the shrub strata because he felt that spiders of the ground stratum were quantitatively much less important.

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Stomach samples taken from lizards showed a low food utilization of ground dwelling spiders, however, Chew pointed out that ground dwelling spiders are probably principally active at night, and may not be adequately sampled by lizards.

From field evidence, I consider that nocturnal ground dwelling spiders, both in size and numbers, play a much more important role in the ecology of a desert community than has been thought.

Lycosa carolinensis Walckenaer is found throughout the United States (Kaston 1953), where in the hot Sonoran desert of Arizona it is active only at night. Specimens collected near Phoenix, Arizona, were identified by Dr. Willis Gertsch of Portal, Arizona, to be *L. c. texana* Montgomery which in Gertsch's opinion possibly is a separate species. Because of its size (up to 12 mm thorax width) and numbers, it could play an important role in the ecology of a creosote bush (*Larrea*), bur sage (*Franseria*) community. Since Chamberlin (1908) revised the family Lycosidae, *L. carolinensis* has been mentioned only briefly by Kaston (1936, 1948), Cole (1946), Kuenzler (1958), Whitcomb and Eason (1964, 1956), Moeur and Eriksen (1972), and Farley and Shear (1973).

Before an assessment of the importance of *L. carolinensis* in the desert community can be made, it is necessary to gather information on certain aspects of the life history, ecology, and behavior of the animal. It was the purpose of this study to investigate the surface activities, seasonal activities, and burrow construction of *L. carolinensis* in the Lower Sonoran Desert.

MATERIALS AND METHODS

Study Areas—In March 1970, a study area (approximately 150 m square) was selected on the Ahwatukee Ranch, Maricopa County, 4 km southwest of Guadalupe, Arizona (elevation 424 m). This portion of the Lower Sonoran Desert is characterized by flat open ground which is occasionally interrupted by shallow washes formed by infrequent run-off.

The flora of the Ahwatukee Ranch study area was analyzed using the point-center quarter method (Cottam and Curtis 1956). The dominant plant is creosote bush, *Larrea tridentata* (DeCandolle) Corville with a relative density of 98% and an actual density of 0.09 plants/m². The remaining 2% of the relative density is made up primarily of scattered bur sage, *Franseria deltoidea* Torrey. Adjacent to the study area, paloverde, *Cercidium microphyllum* (Torrey) Rose and Johnston, and saguaro cactus, *Carnegiea gigantea* (Englemann) Britton and Rose, are present in low densities. Other plant species, including desert annuals and other species of cacti also are present but at lower densities and more scattered in distribution. The soil is sandy and well packed on open expanses, grading to coarse gravel in the bottoms of washes. Under creosote bushes the soil is softer and of finer texture. Extensive surface scratching, burrowing, and digging activities of rodents, lizards, and arthropods, particularly under creosote bushes, are evident throughout the area.

In the late winter of 1972, a second study area, known as the Usery Pass study area, was selected at the junction of Bush Highway and the Usery Pass Road, approximately 52 km northeast of Phoenix, Maricopa County, Arizona. The vegetation of this study area is of the paloverde-bur sage-saguaro type (Lowe 1964). White bur sage, *Franseria dumosa* Gray, is the most abundant dominant. Creosote bush constitutes a minor element in the shrub flora. Scattered paloverde trees and several species of cacti, including saguaro,

occupy the areas between washes. Blue paloverde, *Cercidium floridum* Benthams, and ironwood, *Olneya tesota* Gray, are distributed along the washes along with a relatively lush and varied flora of shrub species.

Surface Activity—Prior to June 1970, several visits were made to the Ahwatukee Ranch for the purpose of locating active spider burrows. The study area was searched after dark several times using a head lamp to create a narrow beam of light that would be reflected from the eyes of the spider. In this manner a spider could be located and by walking over to the spider its burrow also could be found. A small number of spiders were marked with phosphorescent paint as an aid in identification of individuals. Once a burrow was located it was numbered and marked with a wooden stake placed on the north side of the burrow 35 cm from the burrow entrance. During the course of the summer of 1970, any additional burrows that were found on the weekly visits were also marked.

From June until November 1970, weekly visits were made to the Ahwatukee study area. On each of these nightly visits, data were collected at approximately hourly intervals by walking to each active burrow, if the study area was visited from dusk until midnight, or approximately two hour intervals if the visit was from midnight until dawn. At each burrow the position of the spider relative to the burrow entrance was recorded. Data also were collected on any reproductive behavior that was observed or the presence of egg sacs. The distribution of plants and the topography of the ground was mapped for selected burrows to determine more about home ranges.

At the end of the summer, weekly data were compiled and plotted on graph paper to represent the distribution of a spider around its burrow. The outermost points of this distribution were connected by a straight line to form a polygon with the least area. The area of the polygon represented the minimal home range of a particular spider. Using a planimeter, the home range was calculated to the nearest tenth of a square meter.

Seasonal Activity—From March until October 1972, bimonthly visits were made to the Usery Pass study area to collect spiders for the determination of seasonal activity.

On each nightly visit, a random course was walked and approximately 20 spiders were collected at random and preserved in 70% ethyl alcohol. These collected spiders were then brought into the laboratory where sex and carapace width were determined, the latter to be used in ageing the specimens. Dondale (1961) found carapace width to be one of the most reliable morphometric criteria for age determinations.

As each spider was collected, data also were collected on the width of the burrow entrance, height and composition of the turret, presence of tumulus piles, and the distance and species of plant nearest to the burrow.

Field captured spiders of different age groups were brought into the laboratory and introduced into circular metal containers (approximately 18 x 15 cm) two-thirds full of desert soil. These spiders were fed and watered as needed and the soil in their containers was moistened bimonthly. They also were checked weekly for burrowing activity.

RESULTS AND DISCUSSION

Surface Activity—Extreme daily maximum desert soil surface temperatures during the summer, up to 65° C in June (Hadley 1970) and higher in July and August, cause many

desert arthropods to seek subterranean shelter from the heat during the day and to become active at night when temperatures are lower and relative humidity is higher. This species constructs a cylindrical, tube-like, subterranean burrow of approximate body width where it seeks refuge during the day and centers its activity around this burrow at night.

In the Sonoran Desert, this species is almost entirely nocturnal, and during two years of field observation I noted no diurnal movement. However, after heavy summer rains it occasionally has been seen wandering on the surface, probably due to the flooding of the burrow (Honetschlager, personal communication).

The average home range for spiders at the Ahwatukee Ranch study area during the summer of 1970 was found to be 0.8 m^2 for males ($n=9$) and 1.2 m^2 for females ($n=15$). These differences were not significant using a t -test at the 5% level because of the great individual variation. When male and female home range measurements were combined the average home range was 1.1 m^2 (approximately 9 ft.^2).

Only one study to date has measured the home range of lycosid spiders (Kuenzler 1958). By constructing a polygon formed by field location points of the spider at various times, Kuenzler determined the home range of the species in Table 1.

The difference between Kuenzler's results and my results could be due to either habitat differences or sample size differences (3 spiders vs. 23 spiders).

Table 1.—Home ranges of selected species of wolf spiders (from Kuenzler 1958)

Species	Sex	No. Spiders	Average Home Range	
			ft ²	m ²
<i>Lycosa timugua</i> Wallace	Immat.	27	33	3.1
	Male	2	449	41.8
	Female	8	103	9.6
<i>L. carolinensis</i>	Immat.	3	6	0.6
<i>L. rabida</i> Walckenaer	Immat.	2	130	12.1

The shape of the home range was compared to topography and plant distribution, and no clear correlation was found. However, in many cases it appeared that a boundary of the home range was formed by a rapid change in topographical relief. This was particularly noticeable when the home range came in contact with a wash or the mound surrounding a clump of creosote bushes. This delimitation of the home range boundary by rapid changes in topographical relief only occurred when elevational changes were found within a distance of approximately 0.3 to 2.5 m from the burrow depending upon the size and shape of the home range for that particular spider. Figure 1 shows the shape of the home range for female 18 and how her home range is possibly delimited by both changes in topographical relief and the presence of vegetation. I found no discernible delimiting factors for the western edge of the home range. Perhaps there is an innate maximum distance a spider will wander away from its burrow.

The distance from the spider burrow to the nearest shrub was measured to the nearest 0.5 m. When this distribution of distances was compared to a Poisson distribution, it was found that the spider burrows did not occur in a random pattern from the shrubs ($p<0.01$) but were more uniformly distributed.

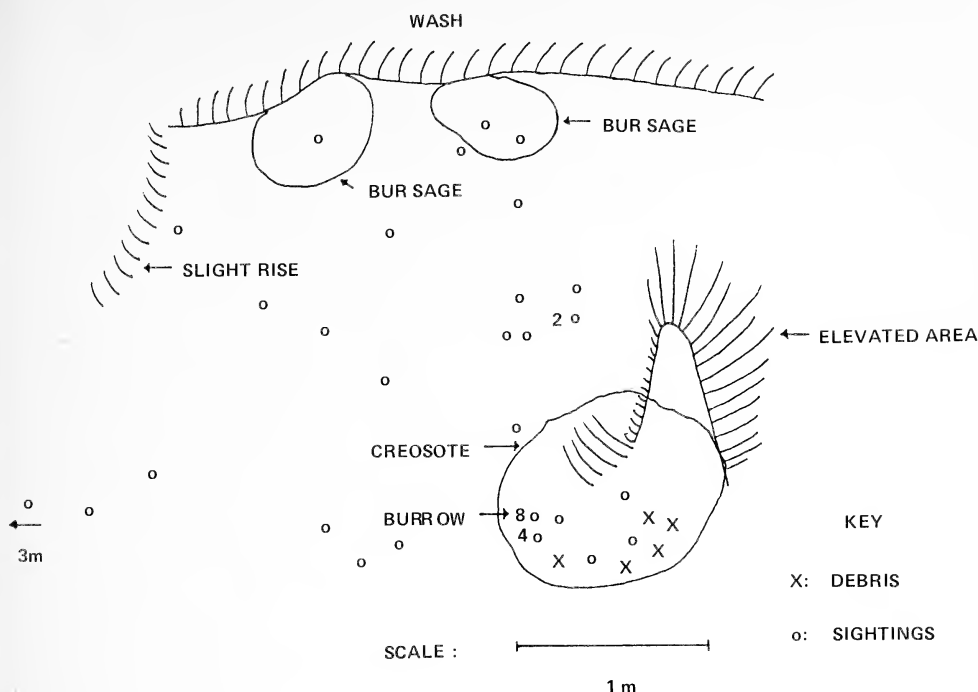


Fig. 1.—Delimitation of the home range of female 18 by changes in topographical relief at the Ahwatukee Ranch study area during the summer of 1970.

Another statistical test (Holgate 1965) was used to determine the distribution of spider burrows at the Ahwatukee Ranch study area. Briefly, random points were chosen and the distance to the two nearest spider burrows was measured. The sum of the ratio of these squared distances was then divided by sample size to obtain an index of distribution, A . According to this test: $A=0.5$, random distribution; $A<0.5$, uniform distribution; $A>0.5$, aggregate distribution. The calculations from the data gathered at the Ahwatukee Ranch produced a value of $A=0.4328$. Although this value is less than 0.5 it is not significantly different from a random distribution at the 0.05 level.

These two tests would indicate that wolf spider burrows were distributed in a random manner throughout the study areas, but at a uniform distance from the shrubs. Both Cole (1946), in a woodland, and Kuenzler (1958), in an old-field habitat, indicate a random distribution for this species.

This random distribution is only valid up to a certain point, because of the cannibalistic tendencies of spiders, no two active burrows were found that had overlapping home ranges. Therefore, interspider distance of burrows was always greater than the maximum wandering distance of the inhabitants of the adjoining burrows and usually, because of the low density of spiders, much greater.

Another explanation of spacing in a desert spider is provided by Riechert (1974). She suggests that the regularity of distribution of webs of the funnel web spider, *Agelenopsis aperta* (Gertsch), in a Chihuahuan desert grassland and recent lava bed habitats in south-central New Mexico is attributed to a social mechanism. The mean spacing of individuals is believed to function to ensure a food base of available prey.

Wolf spiders feeding on the surface were found in very low numbers at both study areas. Out of 674 field encounters with wolf spiders only three were found to be feeding (0.4%). This agrees with Edgar (1969) who found the same infrequent feeding of *L. lugubris* (Walckenaer). Neither this species or *L. lugubris* actively run down their prey but wait until the prey comes close to the spider where it is suddenly captured. This low number could be biased if the spiders left their food upon being disturbed; however, from observations in the laboratory, once a spider captured a prey it was very reluctant to relinquish it. This would indicate that spiders fed infrequently or were capturing prey and transporting it to their burrow to feed

On 7 July 1970, a desert hairy scorpion (*Hadrurus arizonensis* Ewing) was found feeding upon a leg of a female wolf spider about 9 cm from her burrow. She was on the surface and had lost, presumably to the scorpion, all but one leg on the left side of her body. The spider was seen weekly on the surface for the next two weeks before the burrow became inactive.

Other potential predators upon wolf spiders observed in the area include coyotes (*Canis latrans* Say), screech owls (*Otus asio* [Linnaeus]), elf owls (*Micrathene whitney* [Cooper]), and various predatory insects. Cazier (personal communication) has observed the predatory wasp *Cerceris frontata* Say dislodge a wolf spider (*Lycosa coloradensis* Banks) from her burrow.

Seasonal Activity—The monthly percentages of each life stage (immature, adult female, adult male) found at Usery Pass during 1972 are shown in Figure 2. The cross-hatch component of the immature column represents penultimate males. As can be seen from the graph, the highest percentages of immature spiders were found in March and October 1972, the lowest numbers occurred in midsummer. Mature female spiders were found from April through September with a peak number in July, while males also were found in these months, but their peak number occurred in June. No wolf spiders were found active in the months of November through February, and it is known that in cool climates or seasons, wolf spiders enter a state of torpor (Moulder *et al.* 1970). Changes in these populations of "hibernating" spiders are influenced by temperature more than any other physical factor (Elliot 1930).

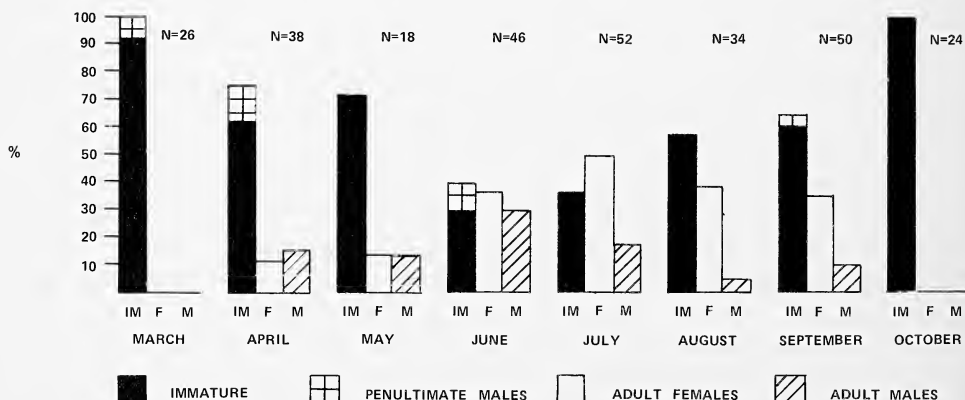


Fig. 2.—Relative percentage of each life stage (immature, adult female, adult male) found in the field during the corresponding month of 1972.

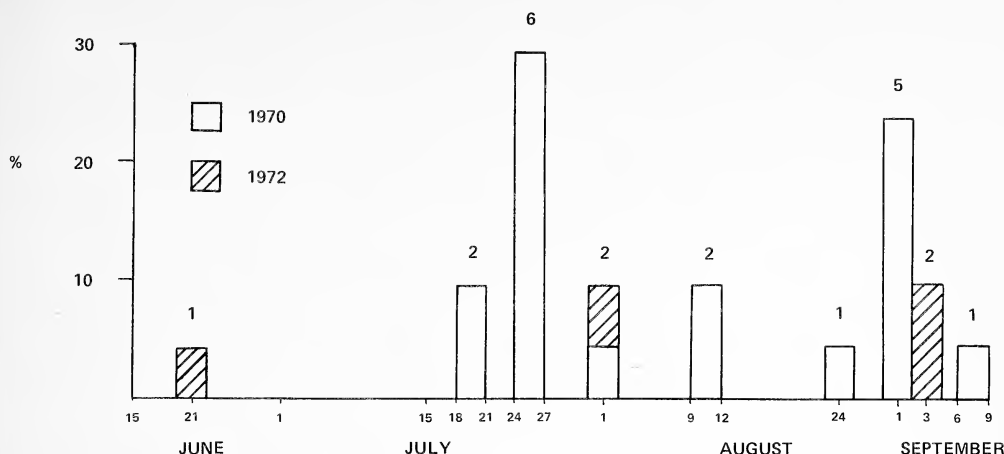


Fig. 3.—Relative percentage of females with egg sacs in the field during different months of the year.

The age classes of spiders above ground during the year was almost opposite to that found by Duffey (1962) in a limestone grassland. He reported that the proportion of adults was never more than 48% during the year, highest in the winter and lowest in the summer (less than 7% in July). The adults in this study were at their highest percentage in the summer, up to 65% in June and July, and at their lowest percentage in the fall. This difference could be for several reasons; first, the adults could “hibernate” at warmer temperatures than the immatures thereby eliminating them from being collected. Second, the immatures might be harder to find at night due to their small size and, therefore, were not collected in the same proportion to their true numbers.

Males were found in their maximum numbers one month before females (June and July, respectively), although in June the percentage of females in the population was higher than that of males as it was for every month (except for April and May). Perhaps males are not as numerous as females in the population or the survival rate of males is less than that of females.

Females were found carrying egg sacs from mid-June to early September (Figure 3), with young on their backs from early July to late September, and that year's young were found in the field from the middle of July to early November.

Figure 3 shows more specifically the period of time that females were found with egg sacs. There are predominantly two main peaks of egg sac carrying, one occurring in the latter half of July and early August and the second occurring in late August and early September. Of 13 egg carrying female spiders observed at the Ahwatukee Ranch during 1970, one was seen on 25 July carrying an egg sac, that young later emerged from, and she was seen carrying a second egg sac on 17, 24, and 31 August. On 8 September, the burrow and turret were in a state of disrepair indicating the spider was no longer active. No young were observed from this second egg sac although in the week between 31 August and 8 September the young could have dispersed. This phenomenon of multiple broods per season has been demonstrated in other lycosids (Turnbull 1966, Vlijm and Kessler-Geschiere 1967).

Female wolf spiders were seen frequently sitting at the top of their burrows, heads down, with egg sacs attached to the posterior part of the abdomen. This behavior was observed primarily before midnight. According to Gertsch (1949) in the diurnal burrowing Lycosidae the female "suns" her eggs during the warmer part of the day to hasten the development. In the desert, the soil surface cools rapidly after sundown (Hadley 1970), air and soil temperatures becoming approximately equal at 2000 hours, while subsoil temperatures lag behind those of the surface. Hadley (1970) found at -20 cm the maximum subsoil temperature in June of 42° C was not reached until 2000 hours. The average depth of 21 burrows that were excavated is 25.5 cm with a range of 18-40 cm. Moeur and Eriksen (1972) found that this species maintained normal activity above 30° C, but as the temperature increased so did the energy requirements of the spider. Perhaps female wolf spiders are selecting a cooler temperature, but one well within the activity range, in which to "incubate" their eggs. Also, from laboratory experience with wolf spider egg sacs, I found that egg sacs were subject to fungus infection in high humidity environments. Hadley (1970) found a relative humidity range of from 55-70% at depths of 20-25 cm. Perhaps by moving to the top of the burrow the egg sac was not subjected to high humidities.

The average measurement for 10 somewhat spherical egg sacs collected in the field and laboratory were $14.1 \times 11.5 \times 10.2$ mm, the mean weight of which was 0.95 g. The sacs contained 112 to 180 eggs with a mean of 149.

Ten females were observed to carry their egg sacs around for a mean of 12.3 days, whereupon the young emerged and climbed upon the female completely covering her abdomen and parts of the cephalothorax and legs. The young remained on the female approximately five days before they dropped to the ground and became independent spiderlings. A few of the young would stay around the mother's burrow for weeks after they emerged but most soon disappeared to find a suitable burrow or construct their own retreat.

In the laboratory, 26 spiders that were raised from spiderlings estimated to be approximately five days old, took on the average an additional 253 days to mature when kept at a constant temperature of 32° C with food and water at one week intervals. During the midactivity season, especially June through August, spiders in the field could easily be subjected to higher temperatures which would speed up development. This would probably be balanced because most of the remaining part of the year they would be subjected to cooler temperatures that would retard development. If a spider hatched in mid-July, in most years it would only have until mid-September to grow under favorable conditions before temperatures cooled and the spider went into a state of torpor for the winter. The next summer could be spent maturing, then the spider would overwinter either as a penultimate or as a mature spider, emerging from its retreat the following spring ready to reproduce in that year. From Figure 2 it can be seen that penultimate males were present both in March and September. The former are probably overwintering spiders that have to molt only once in order to become mature. The latter are males that have almost matured over the summer and are ready to overwinter and reproduce the next year.

It is thought that males die the summer they reproduce. Figure 2 shows a gradual decrease in males from a peak in June until the end of the activity season. Death the year of maturity is a common occurrence for the males of all species (Gertsch 1949).

Females that reproduced in 1970 at the Ahwatukee Ranch were again seen active in 1971. This indicates that mature females overwinter and can reproduce more than just in

the summer they reached maturity. This is supported by the fact that mature females form a much higher percentage of the total population in the latter part of the activity season (July through September) than do the males (Figure 2).

Therefore, field and laboratory evidence suggests that this species probably does not reproduce until their third summer. Following maturity females may live at least one additional summer or possibly more while males die the year they mature. Other authors also have reported biennial species of wolf spiders: Hackman (1954) for *Trochosa pratensis* (Emerton), and Kurata (1939) and Wallace (1942) for *Geolycosa*. Gertsch (1949) found that all burrowing wolf spiders of the United States are large species living more than one year.

Burrows—The function of wolf spider burrows is thought to be one of retreat from the elements as well as from potential predators. Because of extreme daily summer maximum temperatures in the desert the burrow serves as an ideal refuge from heat and lack of moisture until night comes, temperatures cool, and the relative humidity increases. At this time the burrow serves as a center of activity and retreat from some potential predators. At night, this species often would retreat to the burrow at the slightest disturbance even when approached from more than 50 m, while on other occasions a person could approach close enough to capture the spider. On rare occasions, and for undetermined reasons, under harassment the spider would avoid retreating to the burrow and remain on the surface.

Little information is available on the construction or description of wolf spider burrows (see Dumas and Whitcomb 1964, Gwynne and Watkiss 1975, Hannock 1899, Kaston 1948, Kurata 1939, and McCook 1888).

A wolf spider constructs the burrow by spinning a circular-shaped flooring on the ground. She then digs up this mat and moves it to one side with the sand sticking to it. This procedure is repeated until the burrow is dug to the proper depth. The burrow is as big as the spider but enlargements in the diameter of the burrow are made at various levels to allow the spider to turn around (Gertsch 1949).

This species possesses no unique or modified anatomical parts that are used in digging burrows (Gertsch 1949). Its large size and powerful chelicerae are advantageous for digging; however, I propose (from laboratory and field evidence) that this species often does not need to dig its own burrows but possibly takes possession of burrows dug by other desert dwellers such as rodents, lizards, and other arthropods. Several cases were noted of the young taking possession of their mother's burrow at the end of the activity season after she had died or even during the activity season upon the disappearance of their mother. Spiders collected in the field often have a burrow opening with a diameter of 1.2 cm at the surface, but 5 cm below the surface the diameter is 5 or 6 cm, much too large for the spider but approximately the same size as burrows constructed by small rodents found in the area. It would appear advantageous in terms of energy expenditure for spiders not to dig their own burrow if others were available.

Third to fifth instar spiderlings constructed small burrows in the desert soil present in their laboratory containers. Of 70 spiderlings raised in the laboratory 72% constructed small burrows. These burrows were occupied for approximately one instar and then abandoned, and no attempt by the spiderlings to enlarge these burrows was seen. This raises the possibility that these spiders might construct or possess at least two burrows, one when they are extremely small and another as they grow larger.

Of 10 immature spiders brought into the laboratory and housed in metal containers six eventually, after several weeks, constructed burrows. All the spiders constructing burrows matured into females while all those not constructing burrows matured into males. Due to the small sample size it is difficult to know if only females will construct burrows in the laboratory. On other occasions adult wolf spiders did not construct burrows in the laboratory when provided with what was thought to be the necessary materials and optimum edaphic and climatic conditions. *Lycosa narbonnensis* Walckenaer also lives in a permanent burrow and if taken away from the burrow it showed neither the inclination nor ability to dig another one (Savory 1928). The difficulty in getting these spiders to construct another burrow when brought into the laboratory is probably a case of not providing the spider with the proper stimuli instead of the lack of ability on the spider's part to perform this behavior.

The majority of digging and remodeling takes place early in the activity period (March through June). At this time tumulus piles, small mounds of fresh earth, can be found around many of the burrow entrances of all size spiders, indicating digging activity. Later, towards the end of the activity period (August and September) only burrows constructed by that year's spiderlings have tumulus piles present.

Of 76 wolf spider burrows checked, only 10 burrows (13%) did not have a turret (an extension of the burrow above ground usually composed of sticks or grass). The average height of a turret above the soil surface is 1.2 cm. The turret is usually constructed of material found in the immediate area, which is tied together with silk to form a fairly sturdy structure with a smooth lining continuous with the silk of the burrow. The following materials are used by this species to construct the turret: creosote bush and bur sage leaves, dried grasses, small twigs, cholla thorns, small pebbles, and rabbit pellets. The most common materials are small twigs, grasses, and mud. The function of the turret has been proposed by Gertsch (1949) to be that of a lookout; however, for nocturnal spiders the use of the turret for this purpose is probably reduced. I often noticed that the sticks and grasses used in construction of the turret radiate outward from the burrow entrance for several centimeters, and because these sticks and grasses are attached to the lining of the burrow, the turret might serve as an "early warning system" for the wolf spider when it is in the burrow. Vibrations from small animals that moved across these sticks could be transferred down the burrow to the spider thus extending its sensory range. The turret also possibly can prevent water from running down in the burrow during times of excess run-off immediately following light to medium desert rainfall, act as a retardant against intruders, prevent dirt and sand from blowing into the burrow (Gwynne and Watkiss 1975), serve as a recognition signal for the owner, or serve as a place to sit above the hot substrate.

The shape of the burrow varies from a straight vertical tube to a predominantly vertical tunnel with many bends and turns probably representing the path of least soil resistance as the burrow is being dug. Often the bottom of the burrow is slightly enlarged; also, some burrows have exuviae (the cast skin of the spider) attached to the tunnel wall about 20 cm below the surface. Prey remains were not found in the burrows, suggesting that feeding is done above ground.

ACKNOWLEDGEMENT

The author would like to thank Drs. Mont Cazier, David Rasmussen, Wendell Minckley, Duncan Patten, Hugh Hanson, Oscar Francke, Susan Riechert, and B. J. Kaston for reviewing this manuscript. Help in locating potential collecting areas was given by Loren Honetschlager, while use of the Ahwatukee Ranch was made possible by Byron Slawson. This paper is a portion of a dissertation presented in candidacy for the Ph.D. degree in Zoology at Arizona State University.

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REDESCRIPTION OF *CENTRUROIDES KOESTERI* KRAEPELIN (SCORPIONIDA, BUTHIDAE)

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ABSTRACT

The scorpion *Centruroides koesteri* Kraepelin from Costa Rica, previously known only from one female, is redescribed and illustrated. Additional specimens of both sexes come from Provincia de Guanacaste. This species appears to be endemic to northwestern Costa Rica's tropical semi-evergreen and deciduous forest, and to be rather strictly arboreal in habits. Its closest relative is considered to be *Centruroides margaritatus* (Gervais), and differential characters between these, and other related species, are given.

INTRODUCTION

The buthid scorpion *Centruroides koesteri* was described by Kraepelin (1911) from one adult female collected in Costa Rica. Meise (1934) treated all the species of the genus *Centruroides* Marx as members of the genus *Rhopalurus* Thorell, recognized only four polytypic species, and considered *C. koesteri* as a subspecies of *Rhopalurus testaceus* [= *Centruroides testaceus* (Geer)]. Viquez (1935) failed to mention *C. koesteri* in his work on the scorpions of Costa Rica, and was apparently unaware of the publications by Kraepelin (1911) and Meise (1934). Finally, Stahnke and Calos (1977) did not include *C. koesteri* in their key to the species of *Centruroides*, nor did they consider it a valid subspecies as Meise (1934) had, listing it as a junior synonym of *Rhopalurus testaceus* (sic, = *Centruroides testaceus*?).

I have recently examined the holotype of *Centruroides koesteri* Kraepelin, and found that it is a valid species. the study of various collections, as well as personal collecting, have produced 18 additional specimens of *C. koesteri*, providing valuable taxonomic information on this hitherto poorly known species.

Centruroides koesteri Kraepelin
Figs. 1-6

Centruroides kösteri Kraepelin 1911:70; Meise 1934:26.

Centruroides koesteri, Kraepelin 1911:72; Mello-Leitão 1945:255.

Rhopalurus testaceus kösteri, Meise 1934:29, 32.

Rhopalurus testaceus (sic), Stahnke and Calos 1977:119 [nec *Centruroides testaceus* (Geer)].

Type data.—Holotype female, adult, from Costa Rica, 10 June 1905 (H. Köster). Deposited in the Zoologisches Institut und Zoologisches Museum, Hamburg Universität, Germany.

Distribution.—Known only from Provincia de Guanacaste, Costa Rica.

Diagnosis.—Medium sized, adults about 65-75 mm in total length. Yellowish brown with diffuse dark-brown tinging on carapace, post-tergites, and metasomal carinae; mesosomal pretergites with moderately dense, uniform, dark-brown bands submedially. Tergites 1-6 monacinate, tergite 7 pentacinate. Basal piece of pectines in female without median depression. Pectinal tooth count 22-25 in females, 22-26 in males, predominantly 23-24 in both sexes. Metasomal segments I-II decacinate, III with lateral inframedian keels present on distal one-half to one-third, vestigial and sparsely granulose; IV octocinate; all metasomal keels moderately strong, with distinct large granules. Segment V with lateral regions bulging distally, carinae moderately strong and granulose. Pedipalp chela with granulose carinae, manus lighter than fingers, dentate margins of fingers with eight oblique rows of granules.

Description.—Measurements of two females, including holotype, and two males appear in Table 1.

Prosoma—Carapace (Fig. 1) yellowish brown; median eyes, lateral eyes, anterior margin, and lateral margins with dense, uniform dark brown tinging; interocular triangle moderately tinged (appearing medium brown), with distinct dark-brown to black maculae underlying large granules; posterior submedian regions with very diffuse, sparse blackish tinge throughout, and with distinct dark-brown maculae under granules. Interocular triangle of carapace, including anterior margin, densely and coarsely granulose; other carapacial regions moderately granulose. Superciliary carinae moderate to strong, vestigially granulose to subgranulose; other carapacial carinae (Fig. 1) weak to vestigial, subgranulose to moderately granulose. Venter yellow, sparsely setose. Sternum subtriangular with moderately deep, anteriorly directed Y-shaped longitudinal furrow.

Mesosoma—Tergites light yellow-brown. Pretergites shagreened; submedially with dense, uniformly tinged dark brown bands. Post-tergites moderately granulose, lateral margins and submedian areas of posterior margin with sparse to moderate brown to black tinge. Tergal median longitudinal keels weak to moderately strong, bearing medium to large granules; submedian transverse carinae weak, with a few large granules each underlain by dark-brown to black maculae. Post-tergite 7 pentacinate: median, submedian and lateral carinae strong, granulose, maculated. Venter light yellow-brown, sparsely setose. Genital operculi without median longitudinal membranous connection; genital papillae whitish and small in males, absent in females. Basal piece of pectines wider than long, without median depression. Pectinal tooth counts 22-26, predominantly 23-24 in both sexes (in holotype female 23-23, not 22-23 as indicated by Kraepelin, 1911). Sternite 7 with submedian and lateral carinae moderately strong, granulose; median and submedian intercarinal areas smooth, lateral intercarinal areas with dense, small and medium granules.

Metasoma—Yellowish brown dorsally, slightly tinged on lateral and ventral intercarinal areas (appearing medium brown ventrally), with dark brown to black maculations under carinal granules; sparsely setose. Segments I-IV with dorsolateral, lateral supramedian, ventrolateral, and ventral submedian carinae strong, with large, distinct granules. Lateral inframedian carinae on I strong, complete, with large granules; on II weak to moderate, complete, with well-spaced small granules; on III present on distal one-third to one-half, vestigial, with well-spaced small granules; on IV obsolete. Intercarinal areas on I-IV

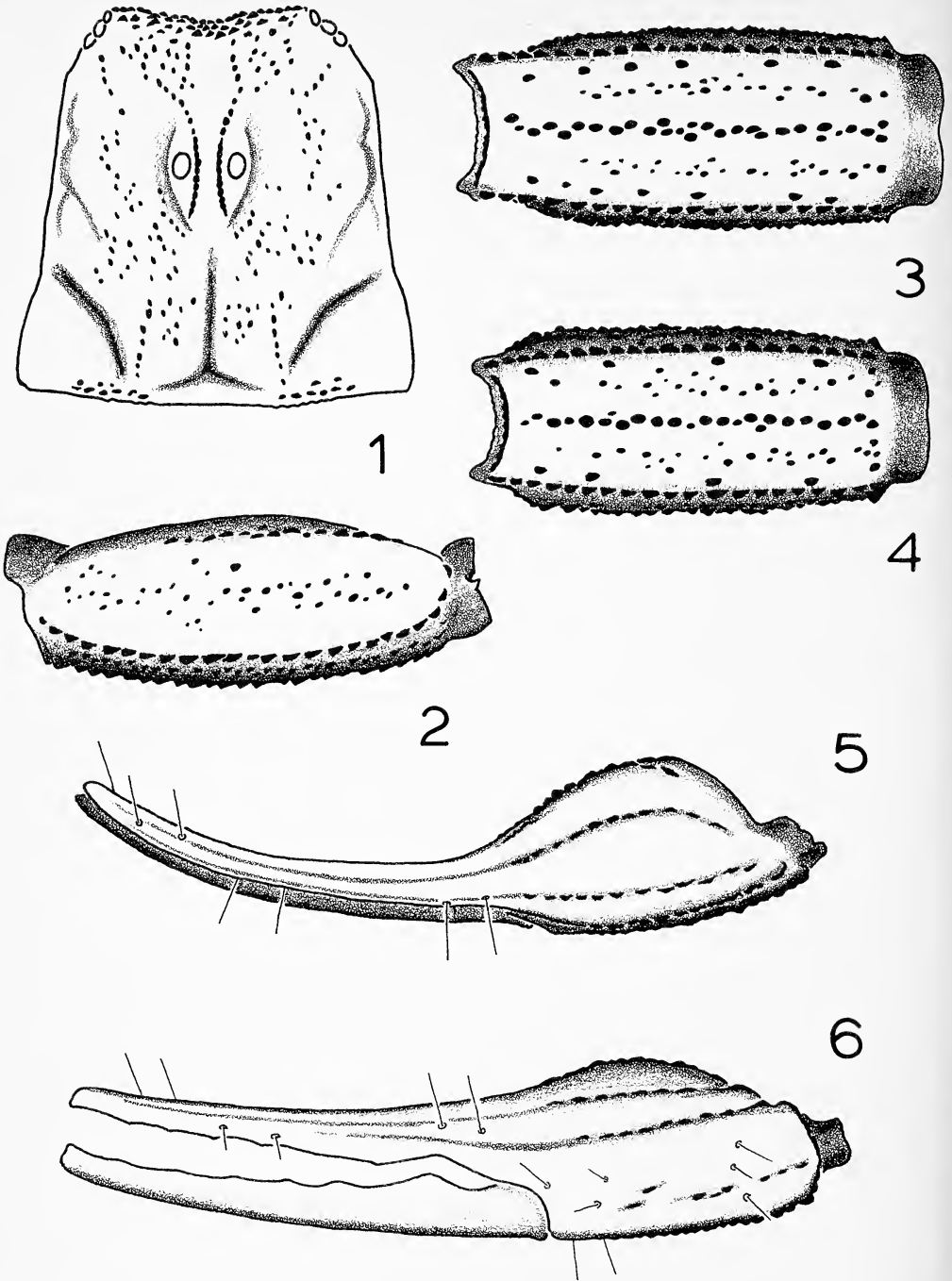
smooth to sparsely, minutely granulose. Segment V (Figs. 2-4) with dorsolateral, latero-medial, ventrolateral, and ventromedial carinae moderately strong, with large granules. Intercarinal areas on segment V: dorsal smooth, laterals moderately granulose; ventrals with keel-like, submedian longitudinal rows of scattered, medium-sized granules. Telson medium brown with moderately dense, uniform dark brown tinging throughout except for one pair of narrow submedian longitudinal bands ventrally; moderately setose, smooth to subgranulose; subaculear spine small, directed towards apex of aculeus.

Chelicera—Yellow to light brown, teeth reddish brown. Dentition on fixed and movable fingers as in other members of the genus.

Pedipalp—Yellowish brown, tibia tinged medium to dark brown distally, chelal fingers reddish brown. Orthobothriotaxia A (Vachon 1974). Femur pentacarinat, keels strong and granulose; dorsal trichobothria in *alpha* pattern (Vachon 1975). Tibia heptacarinat: anterior keels strong, coarsely granulose; other carinae moderate to strong with closely

Table 1.—Measurements (in millimeters) of *Centruroides koesteri* Kraepelin.

	Females		Males	
	Holotype	Adult	Adult	Subadult
Total length	64.40	72.70	74.80	57.30
Carapace length	6.90	7.70	7.20	5.40
Mesosoma length	18.80	21.50	17.60	14.50
Metasoma length	38.70	43.50	50.00	37.40
I length	5.00	5.70	7.00	5.10
width	3.50	4.10	3.40	2.90
II length	6.10	6.90	8.50	6.20
width	3.50	4.10	3.30	2.80
III length	6.60	7.30	9.20	6.70
width	3.50	4.10	3.30	2.70
IV length	7.10	7.90	9.50	7.10
width	3.50	4.05	3.50	2.90
V length	7.50	8.20	9.30	7.00
width	3.50	4.00	3.90	3.20
Telson length	6.40	7.50	6.50	5.30
Vesicle length	3.80	4.50	4.00	3.20
width	2.40	2.80	2.90	2.20
depth	2.20	2.60	2.40	1.80
Aculeus length	2.60	3.00	2.50	2.10
Pedipalp length	25.50	28.50	30.30	23.20
Femur length	6.00	6.90	7.60	5.80
width	1.80	2.10	1.90	1.50
Tibia length	7.00	7.60	8.00	6.40
width	2.60	3.20	2.50	2.10
Chela length	12.50	14.00	14.70	11.00
width	2.90	3.70	4.20	2.20
depth	3.20	3.90	3.00	2.50
Movable finger length	8.20	9.40	9.10	7.10
Fixed finger length	7.10	8.10	8.40	6.20
Chelicera length	3.40	3.70	3.30	2.70
Chela length	2.40	2.60	2.40	1.90
width	1.70	2.00	1.80	1.30
Movable finger length	1.80	2.00	1.80	1.30
Fixed finger length	1.00	1.10	0.90	0.80
Pectinal tooth counts	23-23	23-24	24-24	23-23



Figs. 1-6.—*Centruroides koesteri* from Costa Rica: 1, carapace of holotype female; 2, lateral aspect of metasomal segment V of holotype; 3, ventral aspect of metasomal segment V of holotype; 4, ventral aspect of metasomal segment V of subadult male; 5, dorsal aspect of left pedipalp chela of holotype; 6, exterior aspect of left pedipalp chela of holotype.

spaced, uniform medium granules. Chela (Figs. 5-6): dorsal and ventral keels on internal face moderate to strong, coarsely granulose; dorsomedian keel moderately strong, moderately granulose, extending through length of fixed finger; dorsoexternal keel weak, subgranulose, extending through length of fixed finger; exteromedian keel strong, subgranulose, extending through basal one-half of fixed finger length; exteroventral carina vestigial, subgranulose to smooth; ventromedian keel strong, granulose, directed towards external condyle of movable finger articulation. Dentate margin of fixed finger with eight oblique rows of granules; on movable finger with eight oblique rows, and a short apical "row" of three to four granules.

Legs—Yellow, tibia and tarsomere I with diffuse dark-brown tinging basally.

Variability.—The specimens examined range in carapace lengths from 3.1 to 7.7 mm, and apparently represent five distinct size (and age ?) classes. Smaller individuals (carapace length less than 4.5 mm) in general appear darker than larger specimens, displaying diffuse brownish tinging on the legs and posterior submedian areas of the carapace, moderate tinging on the pedipalps and tergites, and fairly dense tinging on the ventral areas of the metasoma and the interocular triangle of the carapace. The smaller individuals lack the lateral "bulgings" on metasomal segment V which are so distinctive on larger specimens (Figs. 3-4). Individuals considered to be adult or subadult (the two larger size-classes available) have the pedipalp chela fingers reddish-brown, contrasting sharply with the yellowish to light-brown manus; whereas the smaller individuals have fingers the same color, or slightly darker than the manus.

Table 2.- Variability in pectinal tooth counts observed in *Centruroides koesteri* Kraepelin, from Costa Rica. Expressed as the number of combs observed with a given tooth count.

		Tooth count				
	n	22	23	24	25	26
Males	7	3	5	4	1	1
Females	8	1	6	8	1	0
Juveniles	4	2	3	2	0	0

Adult and subadult males differ considerably from all other individuals in metasomal proportions, having segment IV longer than segment V, and the length-to-width ratio of segments II and III greater than 2.0; whereas other sex and age classes have segment IV shorter than segment V, and a length-to-width ratio on segments II and III of less than 2.0. There appears to be no significant intersexual differences in pectinal tooth counts (Table 2).

Specimens examined.—COSTA RICA: no specific locality, 10 June 1905 (H. Köster), holotype female (ZIZMH). *Provincia de Guanacaste*: Playas del Coco (sea level), 19 August 1965 (R. D. Sage), one male (CAS); Rio Sandillal on Panamerican Highway, February 1966 (C. E. Valerio), one teneral subadult male (UCR); Organization for Tropical Studies' Finca "Palo Verde," 6 km NE Puerto Humo (on Río Tempisque), 16-22 January 1978 (C. E. Valerio, W. G. Eberhard, and O. F. Francke), 3 males, 5 females, 4 juveniles (author's collection), 2 males, 2 females (AMNH).

NOTES AND REMARKS

Ecological notes.—The vegetation in Guanacaste Province, Costa Rica, where I have collected *C. koesteri* consists of: (a) tropical semi-evergreen and deciduous forest on slopes with well-drained soils, and (b) tropical scrub and thorn forest on flat areas that are

subject to flooding during the wet season. Both vegetation types have been cleared for grazing in large areas, resulting in (c) an anthropogenic savanna-type vegetation.

Scorpion collecting was done on the three plant formations present; rock- and log-rolling during the day, and with a portable ultraviolet light source at night. Three scorpion species were found, in order of decreasing abundance, as follows: *Centruroides margaritatus* (Gervais), an undescribed diplocentrid, and *C. koesteri*. *Centruroides margaritatus* is the only species found in, but not restricted to, both the scrub and thorn forest and the savanna. It was found using both collecting techniques, under rocks and logs during daytime collecting; and on the substrate, on low vegetation, and on tree trunks at night. *Centruroides koesteri* occurred exclusively in the tropical semi-evergreen and deciduous forest, was taken only at night during blacklight collecting, and appears to be arboreal in habits. Only one of the 16 specimens found in over 20 man-hours of blacklighting was collected on the ground at the base of a tree; the others were on tree trunks and often a considerable distance from the ground. No specimens of *C. koesteri* were found in about as many hours of rock-rolling. Should the arboreal nature of *C. koesteri* be confirmed by future observations, it might explain why this species is relatively rare in collections made before the advent of blacklighting.

Comparative descriptions.—In addition to *C. koesteri*, five species of *Centruroides* known to occur in Central America have eight rows of granules on the fingers of the pedipalp chelae. *Centruroides thorelli* (Kraepelin) is a very small species, adults usually under 45 mm in total length, with dark-brown to black longitudinal stripes on the carapace and tergites, and pectinal tooth counts of 13-18 in females and 18-20 in males. *Centruroides flavopictus* (Pocock) is a medium-sized species, adults about 65-70 mm in total length, uniformly dark colored but sometimes with a lighter median longitudinal band, and pectinal tooth counts of 16-20 in females and 19-22 in males. *Centruroides ochraceus* (Pocock) is a medium-sized species, adults about 65-75 mm in total length, yellowish brown with moderately tinged carapace and tergites, and pectinal tooth counts of 25-28 in females and 28-30 in males. *Centruroides subgranosus* (Kraepelin) is a small species, adults 45-60 mm in total length (in males the metasoma is about eight times longer than the carapace), uniformly yellowish, with an elongate vesicle about three times longer than wide, vestigial carinae on metasomal segment V, and pectinal tooth counts of 22-23 in females and 24-25 in males. *Centruroides margaritatus* (Gervais) is a large species, adults 95-135 mm in total length, medium brown to blackish, and in Costa Rica with pectinal tooth counts of 25-29 in females and 26-34 in males.

Centruroides testaceus (Geer), under which *C. koesteri* had been synonymized by some authors, is known only from the Caribbean islands of Montserrat and Hispaniola. *C. testaceus* is a medium-sized species, adults about 75-85 mm in total length, uniformly light colored except for the darker pedipalp fingers, with obsolete keels on metasomal segment V, with a length-to width ration of metasomal segment I greater than 2.00 in males, greater than 1.70 in females (in *C. koesteri* these ratios are 1.75-2.05 in males, 1.35-1.45 in females), and pectinal tooth counts of 20-22 in females, 23-24 in males.

In addition to the differential characters indicated above, *C. koesteri* is very distinctive in color pattern, the shape of metasomal segment V, the rather large and well-isolated granulation of the metasomal carinae, the presence of weak to moderate lateral inframedian carinae on metasomal segment II, and the extent of granular development on the carinae of the pedipalp chelae. It further differs from *C. margaritatus*, its closest relative in my opinion, in the reduction of carapacial and tergal granulation, the absence

of a median depression in the basal piece of pectines, and the relative proportions of the manus and fingers of the pedipalp chela (fingers proportionately longer in *C. koesteri*).

ACKNOWLEDGMENTS

I am thankful to Dr. Gisella Rack, Zoologisches Institut und Zoologisches Museum, Hamburg Universität (ZIZMH), for the loan of the holotype. To Drs. Paul H. Arnaud and Stanley C. Williams, California Academy of Sciences (CAS), San Francisco, for the loan of numerous specimens. To Dr. Carlos E. Valerio, Universidad de Costa Rica (UCR), San Jose, for the loan of specimens and for making my trip to Costa Rica possible. The Organization for Tropical Studies (OTS), the Universidad de Costa Rica, and Texas Tech University financed and made all the necessary arrangements for that trip. The students of the OTS-UCR sponsored course on Ecology of Tropical Arachnids provided considerable help with the field work. Finally, Dr. D. E. Foster, Dr. W. J. Gertsch, Dr. R. W. Mitchell, Mr. J. R. Reddell, Dr. D. P. Sanders, Mr. M. E. Soleglad, Dr. H. L. Stahnke, Dr. S. C. Williams, and Mr. F. W. Wagner made valuable suggestions on various drafts of the manuscript.

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A NEW GENUS OF THE SPIDER FAMILY DIPLURIDAE FROM CHILE (ARANEAE, MYGALOMORPHAE)

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ABSTRACT

The subfamily Dolichosterninae is newly synonymized with the Diplurinae. A new genus and species, *Mediothele australis*, are established for a Chilean diplurid with six spinnerets but apparently without close relationship to the Hexathelinae.

INTRODUCTION

Traditionally, the Dipluridae have been divided into four subfamilies based primarily on spinneret and tarsal claw characters, without regard for their phylogenetic significance. The Hexathelinae, for example, are defined by the presence of six (rather than four) spinnerets, a character that outgroup comparison with the Mecicobothriidae (apparently the closest relatives of diplurids; Platnick 1977) shows to be plesiomorphic. The subfamily Dolichosterninae (Rainbow and Pilleine 1918, Putrunkevitch 1923) was based on a single female specimen reported to have an unusually long and narrow sternum lacking sigilla; the specimen has been examined and actually has a normal sternum that has been artificially compressed through improper preservation. Since the specimen has two rows of teeth on the superior tarsal claws, the subfamily falls into synonymy with the Diplurinae, which are defined by that character and may well be a monophyletic group. The Macrothelinae, on the other hand, consists merely of those diplurids with four spinnerets that cannot be assigned to the Diplurinae, and hence may possibly be a paraphyletic assemblage.

The new Chilean genus described below highlights the difficulties of this phenetic classification. The spinneret number is six (which would place the genus as a hexatheline), and metatarsi III and IV have preening combs similar to those usually found in hexathelines. Nonetheless, the genus may be more closely related to macrothelines than to any hexatheline; it differs from all known hexathelines (and resembles macrothelines) in being completely devoid of labial and maxillary cuspules. Furthermore, the male palp and the modifications of the first tibia and metatarsus resemble those found in the Australian genus *Cethegus* (Macrothelinae) and in several other South American macrotheline genera. Thus we are unable to place the Chilean form within either subfamily, and merely describe the genus without a certain subfamilial placement because of its importance to future phylogenetic work on the family.

We are grateful to Dr. M. U. Shadab for providing the illustrations.

Mediothele, new genus

Type Species.—*Mediothele australis*, new species.

Etymology.—The generic name refers to the moderately long spinnerets and is masculine in gender.

Diagnosis.—*Mediothele* may be distinguished from all other known diplurids by the combined presence of six spinnerets and a labium and maxillae devoid of cuspules. Furthermore, the genus can be readily separated from the sympatric hexatheline genus *Scotinoecus* by the absence of a palpal conductor.

Description.—Small mygalomorph spiders with three tarsal claws; superior claws with single row of teeth. Six spinnerets, anterior laterals two-segmented and much shorter than single-segmented posterior medians. Posterior lateral spinnerets three-segmented; basal segment with dorsal subsegmentation; apical segment much longer than wide (Fig. 2). Eight eyes in two rows, forming compact group. Fovea small and transverse (Fig. 1). Carapace glabrous. Labium and maxillae lacking cuspules; labium wider than long; maxillae without processes. Sternum with six small sigilla, separated from labium by groove. Chelicerae with single row of teeth on promargin of fang furrow, with single ventral tooth on fang (Fig. 7). Two rows of trichobothria on tibiae, single straight row on metatarsi and tarsi. Metatarsi III and IV with distal preening combs. Males with one large and one small spur on tibia I, and associated thorn on metatarsus I (Figs. 5, 6). Palpal bulb simple, pyriform, with elongate embolus (Figs. 3, 4).

Mediothele australis, new species

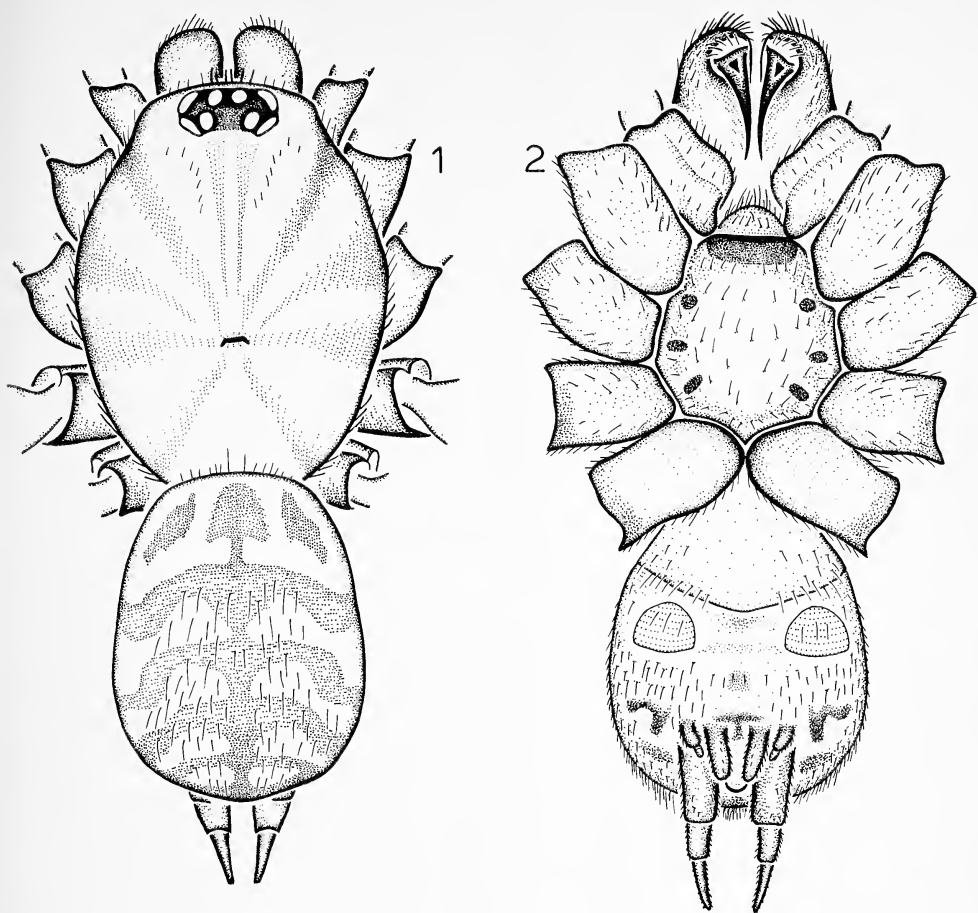
Figs. 1-7

Type.—Male holotype from Hualpén, Concepción, Chile (3 September 1975, A. Quezada), deposited in the American Museum of Natural History.

Etymology.—The specific name refers to the type locality.

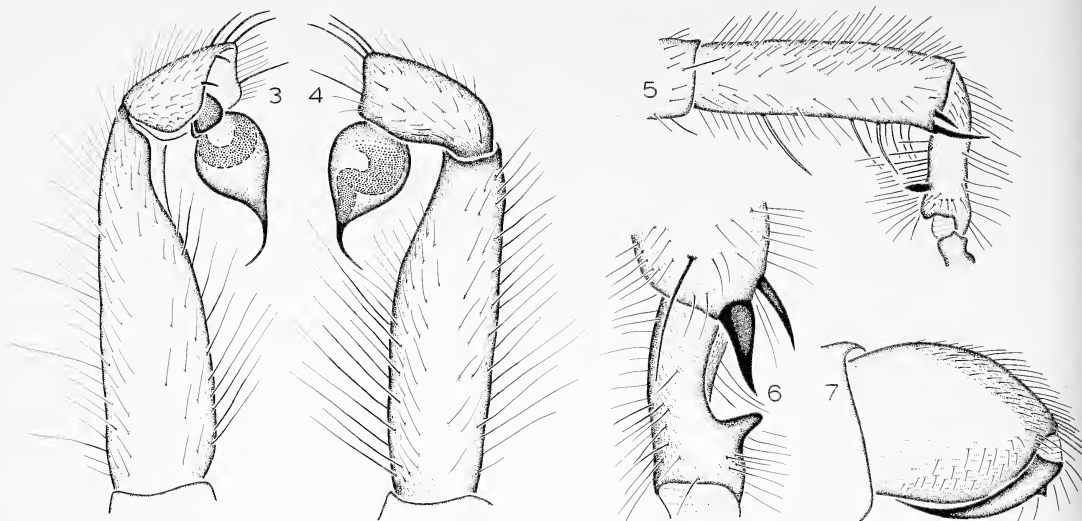
Diagnosis.—With the listed characters of the genus and genitalia as in Figs. 3, 4.

Description.—Total length, including chelicerae, 6.32 mm. Carapace 3.31 mm long, 2.57 mm wide. Abdomen 2.63 mm long, 1.91 mm wide. Carapace and chelicerae uniformly yellowish brown; abdominal dorsum with five brown chevrons posteriorly, with



Figs. 1-2.—Body of *Mediothele australis*: 1, dorsal view; 2, ventral view.

chevrons reduced to pair of brown fields anteriorly; venter mainly white with several small brown fields. Carapace with single row of marginal bristles and 13-15 bristles posterior and lateral of eyes. One pair of short foveal bristles. Some bristles between PME, and on clypeal edge in front of AME. Caput low, gently curved. Clypeus narrow. Fovea a straight wide groove with recurved edges. Eyes occupying about half of cephalic width, ocular area length to width ratio 22:42. Lines joining eye-centers recurved for both rows. Median ocular quadrangle length: front width: back width ratio 20:27:21. Ratio of eye diameters, AME:ALE:PME:PLE, 9:14:10:8. Eye interdistances as proportions of AME diameter: AME-AME 2/9, AME-ALE contiguous, ALE-PLE 3/9, PME-PLE 1/9, PME-PME 13/9. Chelicerae short, slightly geniculate, clothed dorsoapically with numerous curved bristles, almost immovable in their bases. Promargin with eight teeth, basally with an intermediate row of 15 fine denticles irregularly placed. Fang with proximal external tooth. Labium width to length ratio 5:3, quadrangular, anterior edge more or less straight, covered only with long bristles. Maxillae length to width ratio 57:30, quadrangular, with slightly produced posterior basal end, armed only with long bristles. Serrula composed of 15-20 scattered teeth. Sternum cordate, length to width ratio



Figs. 3-7.—*Mediothele australis*: 3, palp, prolateral view; 4, palp, retrolateral view; 5, tibia and metatarsus I, prolateral view; 6, tibia and metatarsus I, dorsal view; 7, chelicera, retrolateral view.

90:76; six sigilla present as ill-defined oval depressions separated from margin by about their respective diameters. Ratio of posterior:median:anterior sigilla diameters: maximal sternal width 5:4:4:76. Leg formula 1423, measurements in mm:

	I	II	III	IV	Palp
Femur	3.04	2.28	2.28	2.80	1.96
Patella	1.64	1.12	1.20	1.20	1.00
Tibia	2.08	1.40	1.28	1.92	1.20
Metatarsus	1.40	2.60	1.73	2.08	---
Tarsus	<u>1.60</u>	<u>1.88</u>	<u>1.20</u>	<u>1.32</u>	<u>0.64</u>
Total	9.76	9.28	7.69	9.32	4.80

Legs covered with bristles but not hairs. Glabrous areas ill-defined on patellae. Tibia I with proximal distoventral spur and proximal spine adjacent to spur base. Metatarsus I with proximoventral erect thorn. Distal half of tarsus I noticeably dilated. No true scopulae but some scopuliform hairs on all tarsi. True spines on all legs: Leg I, femur d5, patella p2, v6 (thickened bristles), tibia v2 (plus spurs), metatarsus with thorn only, tarsus 0; Leg II (regenerated), femur d7, patella 0, tibia v5, metatarsus v5, tarsus 0; Leg III, femur p1, d7, patella 0, tibia p2, d2, r3, v6, metatarsus p3, d1, r2, v8, tarsus 0; Leg IV, femur p1, d7, patella 0, tibia p2, r3, v6, metatarsus p6, r3, v8, tarsus v1; Palp, femur d3, patella d2, tibia 0, tarsus 6 distal. Two preening combs on ventrodistal apex of metatarsi III and IV; those on IV each composed of four teeth of variable length, on III of three teeth and poorly defined. Tarsal organ one-fifth of tarsus from end, roughly the diameter of trichobothrial bases. No lyriform organs evident on posterior patellae or ventral tibiae. Superior tarsal claws with single row of six uniformly spaced teeth; inferior tarsal claw bare. Two rows of four trichobothria on all tibiae; single straight row of four or five trichobothria on all metatarsi and tarsi. Apical segment of anterior lateral spinnerets very small, with about three spigots; posterior medians with numerous spigots. Basal segment of posterior laterals with distinct dorsal subsegmentation slightly evident retrolaterally.

Material Examined.—Only the holotype from central Chile.

LITERATURE CITED

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- Rainbow, W. I., and R. H. Pulleine. 1918. Australian trap-door spiders. *Rec. Australian Mus.* 12:81-169.

RESEARCH NOTE

A NEW RECORD FOR THE RARE OPILIONID *FUMONTANA* *DEPREHENDOR* (OPILIONES, TRIAENONYCHIDAE)

The rare opilionid *Fumontana deprehendor* was described by Shear (*J. Arachnol.* 3:177-183, 1977) from specimens collected in Greenbrier Cove, in the Great Smoky Mountains National Park. A second locality for the species has now been established. Dr. W. B. Muchmore collected a male and female of this species at Joyce Kilmer Memorial Forest near Robbinsville, Graham Co., North Carolina, on 26 June 1977, under a stone in a virgin cove hardwoods forest. The specimens are essentially similar in all respects to the types.

The new locality is 55 km due southeast of the type locality, in a different mountain system, suggesting that further searching might turn up more specimens of *F. deprehendor*. The two localities so far discovered have in common the fact that they are in rich, well-developed mixed forest.

William A. Shear, Department of Biology, Hampden-Sydney College, Hampden-Sydney Virginia 23943.

BOOK REVIEW

INSECT ECOLOGY by Peter W. Price, John Wiley and Sons, New York. 514 pp. (\$16.75).

In the past 20 years, ecology has undergone tremendous growth as a science. A diverse and imposing literature has developed so rapidly that many biologists have missed "catching up" on important, modern ideas in ecology. Moreover, the ecological literature would seem to be dominated by studies with vertebrates (particularly birds), so that invertebrate zoologists, and especially arachnologists have little interest in reading that literature. What is needed is a text in modern ecology written from the point of view of someone who works with invertebrates, and particularly arthropods, with references to organisms whose biology we understand well. Arachnologists, entomologists and other invertebrate zoologists should be pleased that *Insect Ecology*, by Peter W. Price does much to meet this need.

Price's book is written as a text for a course "for advanced undergraduates and graduate students in entomology." Price states that his general theme is to familiarize the reader with current ecological literature, "emphasizing the important role that studies of insects have played in ecological thought, the significance of insects as members of communities, and their potential value in resolving many debates in ecology." With this goal in mind, I think Price has done an admirable job. This fine book provides a thorough coverage of most areas of ecology, and is very well-written. I found most of it easy to read and generally stimulating. Numerous diagrams and illustrations are used to clarify concepts, and aid reader interest. An extensive index makes this book a valuable reference text as well.

The book is organized into four major parts, each with a brief introduction: I—Trophic relationships, II—Populations, III—Coexistence and competition, and IV—Communities and distributions. Within each section are 4 to 6 chapters, preceded by an outline. This organizational format is quite useful in locating information on particular topics, although it makes it difficult to read the book in entirety. In several cases, a topic may be placed out of sequence in different parts. For example, some aspects of predator-prey interactions are in a chapter on "coevolution of predator and prey" and in another chapter on "predator-prey population dynamics." These are both in the section on Trophic relationships, which precedes the introduction to populations. Despite these complaints, the organization of the book is logical, and in general leads the reader through concepts well.

Price's general bent is towards evolutionary ecology, and he is at his best when discussing evolutionary concepts. His chapters are taken from lectures in his course at Illinois (I was a student, and thus am probably given to bias), and several stand out as quite excellent: coevolution of plants and herbivores, energetics of locomotion and evolution of insect flight, strategies of reproduction, the niche concept and division of resources. There are also interesting chapters on specialized topics like populations under insecticide stress, biological control, pollination ecology, social insects and biogeography. The only weakness in coverage is in the community ecology section where a rather well-developed topic of much discussion in the literature (diversity and stability) is treated briefly. Overall, the coverage ranges from adequate to thorough, with most chapters receiving the latter designation.

Arachnologists and others will be disappointed at the only occasional references to non-insect groups, although this should be expected given the title. Still, despite a variety of interesting and significant papers on the ecology of spiders, only three are mentioned. Perhaps the coverage will be better in the next edition.

In summary, I found this book to be excellent for updating one's knowledge of ecology in general, and for learning about the evolutionary ecology of insects in particular. Arachnologists interested in obtaining a good, basic text in ecology with a perspective they can relate to would do well to choose this one.

George W. Uetz, Department of Biological Sciences, University of Cincinnati, Cincinnati, Ohio 45221.

NOMENCLATURAL NOTE

Opinion 1083 of the International Commission of Zoological Nomenclature (Bull. Zool. Nomencl. 24 (1): 30-32) suppressed the generic name *Dapanus* Hentz 1837 and places it on the Official Index of Rejected and Invalid Generic Names in Zoology (Invalid name no. 2087) and placed *Pisaurina* Simon with the type-species by monotypy *Dolomedus mirus* Walckenaer, 1837 on the Official List of Generic Names in Zoology with the name no. 2046. This was voted on 22 September 1976, with affirmative ballots 21, negative none, and abstention one, and was certified by the secretary R. V. Melville on 1 March 1977.

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The American Arachnological Society was founded in August, 1972, to promote the study of the Arachnida, to achieve closer cooperation between amateur and professional arachnologists, and to publish *The Journal of Arachnology*.

Membership in the Society is open to all persons interested in the Arachnida. Annual dues are \$12.50 for regular members, \$7.50 for student members. Correspondence concerning membership in the Society must be addressed to the Membership Secretary. Members of the Society receive a subscription to *The Journal of Arachnology*. In addition, members receive the bi-annual newsletter of the Society, *American Arachnology*.

American Arachnology, edited by the Secretary, contains arachnological news and comments, requests for specimens and hard-to-find literature, information about arachnology courses and professional meetings, abstracts of the papers presented at the Society's meetings, address changes and new listings of subscribers, and many other items intended to keep arachnologists informed about recent events and developments in arachnology. Contributions for *American Arachnology* must be sent directly to the Secretary of the Society.

The Eastern and Western Sections of the Society hold regional meetings annually, and every three years the sections meet jointly at an International meeting. Information about meetings is published in *American Arachnology*, and details on attending the meetings are mailed by the host(s) of each particular meeting upon request from interested persons. The next International meeting will be held during the summer of 1981, and is tentatively scheduled to take place at The University of Tennessee, Knoxville, Tennessee. The 1979 Regional meetings are scheduled as follows:

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Hope College
Holland, Michigan 49423
Dates:

Western section:

Dr. Norman V. Horner (host)
Biology Department
Midwestern State University
Wichita Falls, Texas 76308
Dates:

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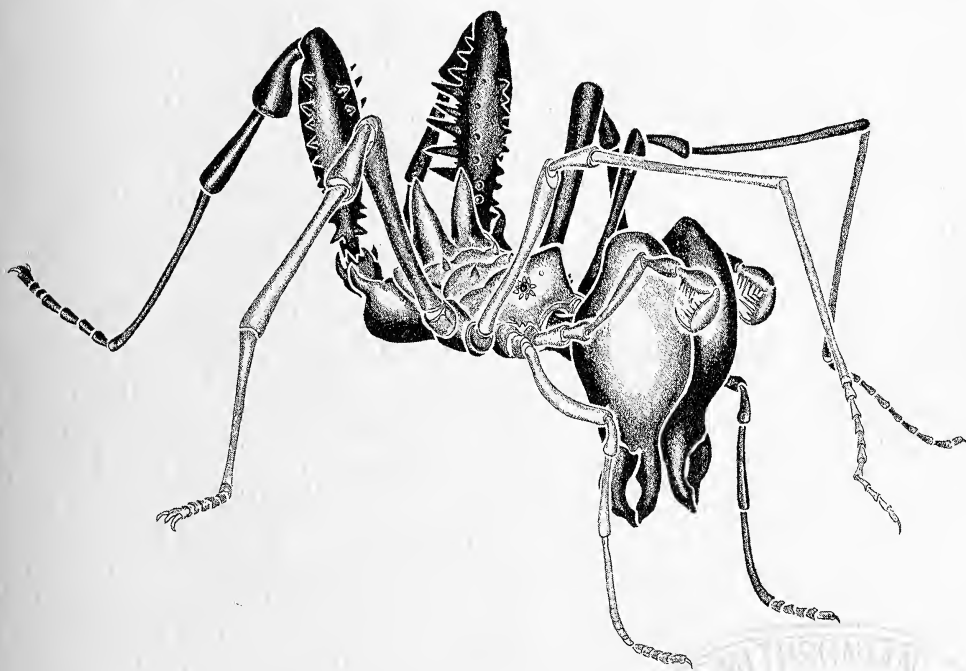
Cover Illustration by William A. Shear
Printed by the Speleo Press, Austin, Texas

Posted at Warrensburg, Missouri, U.S.A., September 1978

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The Journal of ARACHNOLOGY

OFFICIAL ORGAN OF THE AMERICAN ARACHNOLOGICAL SOCIETY



VOLUME 6

SPRING 1978

NUMBER 2

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Change of address notices must be sent to both the Secretary and the Membership Secretary.

Manuscripts for *THE JOURNAL OF ARACHNOLOGY* are acceptable only from current members of the Society, and there are no page charges. Manuscripts must be type-written double or triple spaced on 8.5 in. by 11 in. bond paper with ample margins, and may be written in the following languages: English, French, Portuguese, and Spanish. Contributions dealing exclusively with any of the orders of Arachnida, excluding Acari, will be considered for publication. Papers of a comparative nature dealing with chelicerates in general, and directly relevant to the Arachnida are also acceptable. Detailed instructions for the preparation of manuscripts appear in the Fall issue of each year, and can also be obtained from the Editor. Manuscripts that do not follow those instructions will be returned to the author(s) without the benefit of review. Manuscripts and all related correspondence must be sent to Dr. Oscar F. Francke, Editor, Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409, U.S.A.

Benedict, E. M. and D. R. Malcolm 1978. The family Pseudogarypidae (Pseudoscorpionida) in North America with comments on the genus *Neopseudogarypus* Morris from Tasmania. J. Arachnol. 6:81-104.

THE FAMILY PSEUDOGARYPIDAE (PSEUDOSCORPIONIDA)
IN NORTH AMERICA WITH COMMENTS ON
THE GENUS *NEOPSEUDOGARYPUS* MORRIS FROM TASMANIA

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ABSTRACT

The North American genus *Cerogarypus* Jacot is synonymized under the similarly distributed genus *Pseudogarypus* Ellingsen, together with a redescription of *Pseudogarypus* and a brief diagnosis of the Tasmanian genus *Neopseudogarypus* Morris. *Cerogarypus agassizi* Jacot is synonymized under *Pseudogarypus bicornis* (Banks). *Pseudogarypus banksi* Jacot, *P. bicornis* and *P. hesperus* Chamberlin are redescribed from type series and numerous new specimens; extensive distributional data are given. A new species, *P. spelaeus*, from Samwell Cave, California, is described.

INTRODUCTION

This paper, one of a series resulting from studies of pseudoscorpions collected in Oregon, reports on the species of the family Pseudogarypidae Chamberlin from North America. Although pseudogarypids seem to be distributed widely in the United States, relatively few specimens have been reported and several species have not been adequately described by modern standards. Not only are original diagnoses unfortunately brief, but in some cases descriptive terms are inadequately defined, type specimens are limited in number, and certain of these are in poor condition. This situation has discouraged workers from making specific determinations, resulting in a lack of knowledge concerning interspecific and intraspecific variation. In fact, it has become increasingly apparent that all species must be re-evaluated before further specimens can be identified correctly. For example, Nelson (1975) reported that neither he nor Muchmore were able to find "reliable criteria to establish the Michigan specimens as a new or existing species" (p. 283).

A large number of pseudogarypid specimens from various localities in North America have accumulated over the years in the Muchmore and authors' collections. Recently Benedict and Malcolm collected pseudogarypids from over 35 localities in Oregon which

appeared to fall into three series: one clearly identifiable as *Pseudogarypus hesperus* Chamberlin, one resembling *P. bicornis* (Banks) and the other series apparently differing from either species. In addition, three different series have been recovered from caves or fissures in California and Arizona (Muchmore, pers. comm.). Due to the complex systematic problems, these specimens could not be assigned to species with any degree of confidence. In an attempt to resolve these problems, the authors have examined over 200 specimens, including the types of all extant species of the family. This paper reports the results of this study and presents a clarification of the systematic affinities of the genera within the family Pseudogarypidae; a redescription of the genus *Pseudogarypus*; redescrptions and numerous new records for *P. bicornis*, *P. hesperus*, and *P. banksi* Jacot; and the description of *P. spelaeus*, new species, from Samwell Cave, California. In an attempt to clarify structural terms and relationships each species is extensively illustrated. Comparable structures are drawn to the same scale in all figures.

Family PSEUDOGARYPIDAE Chamberlin

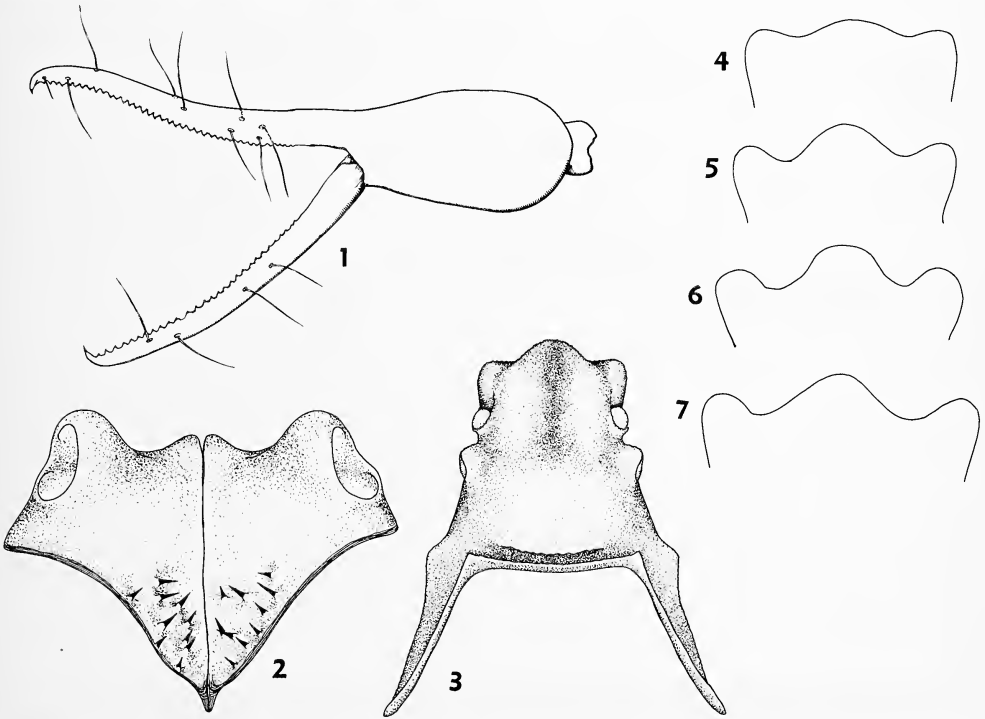
Pseudogarypinae Chamberlin 1923:161.

Pseudogarypidae Chamberlin 1931:230; Morris 1947:43; Hoff 1956:2.

The family Pseudogarypidae traditionally has been considered to consist of the genus *Pseudogarypus* Ellingsen with three extant species and three fossil species, and the monotypic genera *Cerogarypus* Jacot and *Neopseudogarypus* Morris.

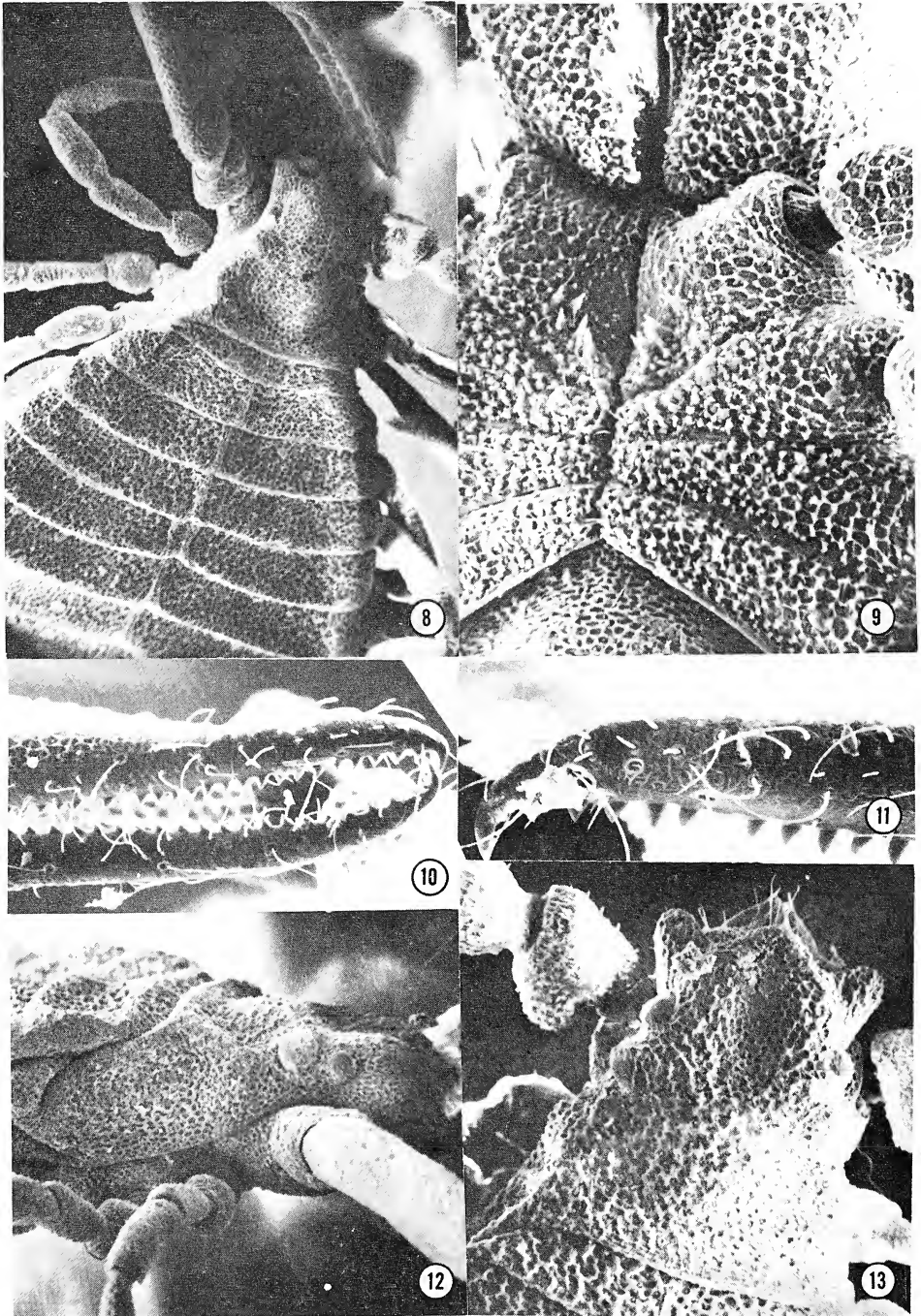
Ellingsen in 1909 recognized that specimens from Yellowstone National Park, Wyoming, previously described by Banks (1895) as *Garypus bicornis*, did not conform to the generic definition of *Garypus* Koch. Therefore, he erected the genus *Pseudogarypus* for the Wyoming specimens, and for a single pseudoscorpion collected at Shasta Springs, California, which he determined as the same species. Chamberlin (1923) described *P. bicornis* in detail, not from Banks' type series but from a single specimen collected at Bear Lake, Utah, which he considered to be conspecific. In 1931, Chamberlin described *P. hesperus* from two female pseudoscorpions collected at Puyallup, Washington. He differentiated this new species from the earlier Utah specimen of "*P. bicornis*" on the basis that, among other characteristics, it exhibited well developed "pseudocoxal spines" on coxae I. Jacot (1938) described the species *P. banksi* from New Hampshire specimens. These also possessed well-developed spines on coxae I. In the same paper, Jacot created the taxon *Cerogarypus agassizi* for Chamberlin's Utah specimen of "*P. bicornis*" because it exhibited "no spines on mesal end of pedal coxae I, and no sclerotized roof over posterior eye" (p. 301). Hoff (1946) upon re-examination of Banks' type specimens of *P. bicornis* (the generotype of *Pseudogarypus*) confirmed the presence of "pseudospines" on the first coxae just as Jacot had implied and gave support to the idea that there were two North American genera of pseudogarypid pseudoscorpions: *Pseudogarypus* and *Cerogarypus*. At about this time, Morris (1947) added the genus *Neopseudogarypus* from Tasmania. He distinguished this genus on the presence of three rows of "chitinised plates" in the pleural membrane. Thus for the past 30 years three genera have been assigned to the family. While the history of these taxa appears relatively straightforward, great confusion exists as to the terminology used by certain authors and to the systematic affinities within the family.

The genus *Cerogarypus* Jacot presents special problems since it is known only from one specimen which is in poor condition. The exoskeleton appears very thin, eroded and stretched as a result of KOH treatment. Careful examination of the male holotype under phase optics reveals that exceedingly minute basal fragments of pseudospines are still present on the first coxae suggesting that the major portions of the spines were broken off during specimen preparation. The fragility of the pseudospines is readily apparent, e.g., the holotype of *P. hesperus* has only one remaining unbroken spine while the rest are stubs of varying lengths. A further area of confusion results from Jacot's statement that *Cerogarypus* has "no sclerotized roof over posterior eyes" (p. 301). This phrase is puzzling. It is true that the specimen lacks both pigmentation and sclerotization of the dorsal portion of the posterior eye tubercle. Again, this may reflect an artifact of specimen preparation. However, specimens of *Pseudogarypus* do exhibit a continuum of variation from a total lack of pigmentation and sclerotization to dark pigmentation and heavy sclerotization in this area. One specimen is heavily pigmented and sclerotized above one posterior eye and not above the other. This character can be most easily viewed under a stereoscope where it appears in some specimens as light-colored and shiny. Therefore, this study shows that the genera *Pseudogarypus* and *Cerogarypus* cannot be discriminated on the basis of Jacot's criteria. Examination of the types of *C. agassizi* and *P. bicornis*, as well as numerous specimens of *Pseudogarypus* from various localities, reveals no other essential differences between the two genera; thus the authors conclude that *Cerogarypus* Jacot is a junior synonym of *Pseudogarypus* Ellingsen.



Figs. 1-3.—*Neopseudogarypus scutellatus* Morris, drawn from female: 1, external aspect of chela; 2, coxae I showing details of pseudospines; 3, carapace.

Figs. 4-7.—*Pseudogarypus* Ellingsen, comparison of anterior margins of female carapace, drawn to same scale: 4, *P. banksi* Jacot; 5, *P. hesperus* Chamberlin; 6, *P. bicornis* (Banks); 7, *P. spelaeus*, new species, allotype.



Figs. 8-10.—*Pseudogarypus banksi* Jacot, scanning electron micrographs: 8, dorsal view of body (50X); 9, coxal area showing pseudospines on coxae I (250X); 10, chelal fingers showing teeth (250X).

Fig. 11.—*Pseudogarypus bicornis* (Banks) tip of fixed chelal finger showing teeth (250X).

Figs. 12-13.—*Pseudogarypus hesperus* Chamberlin: 12, lateral view of carapace showing eyes (56X); 13, dorsal view of carapace showing fingers of chelicerae (100X).

When Morris (1947) erected the genus *Neopseudogarypus* for certain Tasmanian specimens, he described the pleural membrane of *N. scutellatus* as raised into three folds with "a row of chitinated plates" (p. 45) in each fold. At that time he revised the diagnosis of the family "to include forms in which 'abdominal pleural plates are either absent or present'" (p. 43). The authors and Muchmore (pers. comm.) have observed somewhat similar sclerites in some specimens of *Pseudogarypus*, especially males. These sclerites, when present, are weakly-developed and not as uniformly shaped nor as definite as those of *Neopseudogarypus*. The sclerotization may be so poorly developed on some specimens of *Pseudogarypus* that it is nearly impossible to discern unless the pleural membrane is mounted flat. Many females lack these structures entirely.

The discovery of pleural plates in *Pseudogarypus* raises the question as to whether or not it and *Neopseudogarypus* are synonymous. Although there are no longer any distinguishing criteria as defined by Morris (1947), specimens from North America and Tasmania do differ in the arrangement of pseudospines on coxae I, in the form of the abdominal sclerites, the shape of carapace, and in the shape of the chelal fingers. In addition, North American pseudogarypids, though divisible into several species, resemble each other much more than they do Tasmanian pseudogarypids. The authors, therefore, recognize both *Pseudogarypus* Ellingsen and *Neopseudogarypus* Morris as distinct genera.

Pseudogarypids may be recognized by fealloid facies (Chamberlin 1931), no specialized articulation between cephalothorax and abdomen, carapace with pleural alae or processes, abdomen with or without pleural sclerites, coxae I with pseudospines, and pedipalps of normal prehensile form. Tactile setae of movable chelal finger subequally distributed in a linear row on distal two-thirds of finger. Tactile setae of fixed finger roughly distributed as follows: IST and EST forming a medially located pair distinctly separated from more basally grouped IB, EB, ISB, and ESB and distally placed IT and ET; IT about one-fifth length of finger from tip; ET about one-half that distance from tip. Absolute placement of individual setae varies within a given species.

A comprehensive study of *Neopseudogarypus* based upon large series of specimens is necessary before it can be fully characterized. However, the following couplet will separate non-fossil specimens of the presently recognized genera of Pseudogarypidae.

Fixed finger of chela strongly recurved (Fig. 1); several pseudospines arise from posterior margin of coxae I (Fig. 2); carapace with distinct, well-developed posterior suture and posterior margin elevated into high ridge (Fig. 3); pleural plates strongly developed in both males and females; from Tasmania . . . *Neopseudogarypus* Morris
Fixed finger of chela relatively straight (Figs. 15, 23, 28, 30); all pseudospines arise at least one spine's length from posterior margin of coxae I (Figs. 20, 22, 25, 31); carapace with weak posterior suture and posterior margin weakly elevated (Figs. 18, 19); pleural plates lacking or weakly developed in some specimens and relatively well-developed in others; from North America *Pseudogarypus* Ellingsen

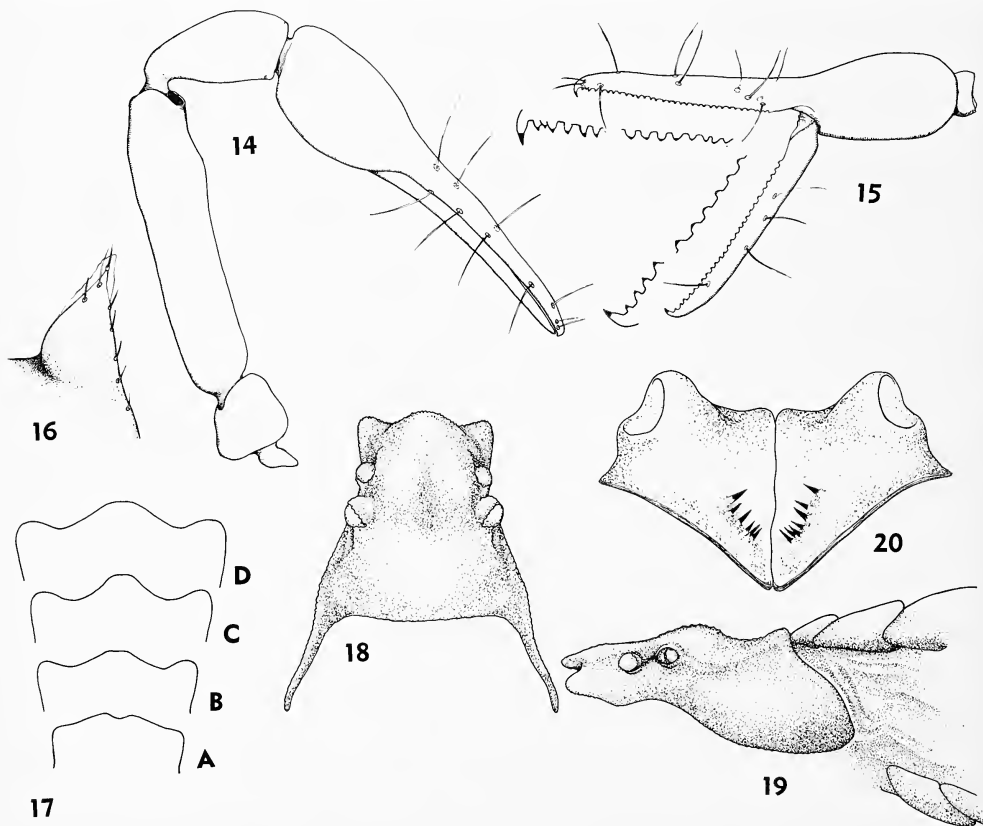
Genus *PSEUDOGARYPUS* Ellingsen

Pseudogarypus Ellingsen 1909:217 (type species, *Garypus bicornis* Banks); Banks 1911:637; Chamberlin 1923:146, 161, 1931:321; Jacot 1938:301; Hoff 1961:442.
Cerogarypus Jacot 1938:301 (type species, *Cerogarypus agassizi*). NEW SYNONYMY.

Diagnosis.—As described in key to genera.

Description.—Exhibits typical feaelloid facies (Chamberlin 1923, 1931). Derm of entire animal heavily rugose-tessellate making minute simple vestitural setae barely discernible. Known range of palpal chelal length (including pedicel) 1.1-2.0 mm; body length (exclusive of chelicerae) of male 2.2-3.2 mm, of female 2.3-3.4 mm.

Carapace (Figs. 12, 13) very irregular in outline and conformation. Anterior margin from dorsal view appearing sinuate with more or less prominent notch or indentation on each side of bluntly rounded median anterior protuberance (Figs. 4-7). Lateral carapacial aspects strongly sclerotized, extending ventrad nearly to coxal area, thus markedly reducing pleural area, and extending caudad to about middle of coxae III as very distinctive, extremely prominent, concave or "spoon-shaped" projections or "lateral alae." Carapace, exclusive of lateral alae, subtriangular and 1-1.25 times longer than posterior breadth. Cucular furrow a broad, shallow, central depression which becomes obsolete anteriorly, extending forward from convex hillock or elevated median disc of pars thoracica. A so-called "antero-lateral protuberance" or "horn," a characteristically prominent, conical projection, arises beneath eye tubercle and extends forward almost even with anterior carapacial margin on both sides of median protuberance. Moderate to well-developed anterior eyes weakly tuberculate and located 2-2.5 ocular diameters from



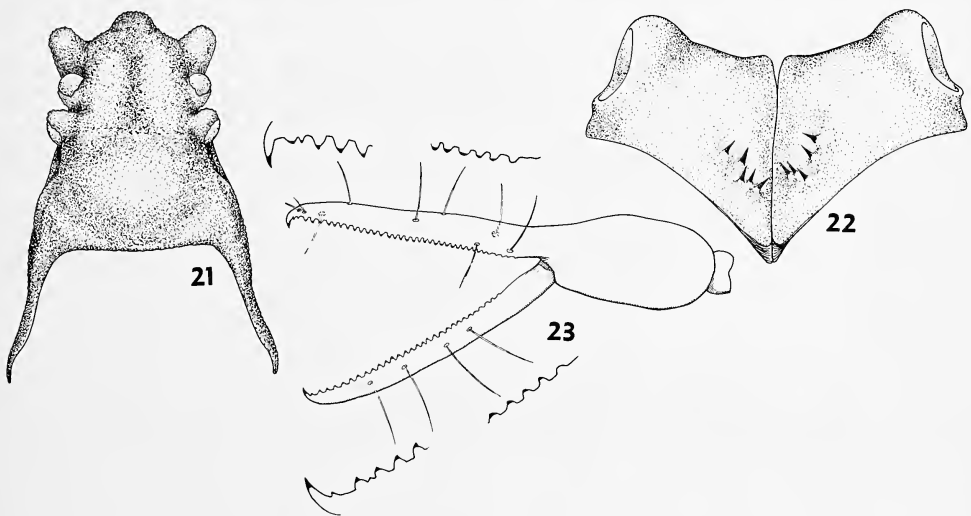
Figs. 14-20.—*Pseudogarypus banksi* Jacot: 14, dorsal aspect of palp of female (cotype MCZ-315); 15, external aspect of chela of male showing details of teeth; 16, apex of maxilla; 17, comparative development of anterior carapacial margin: a—protonymph, b—deutonymph, c—tritonymph, d—adult male; 18, dorsal view of carapace; 19, lateral view of carapace; 20, coxae I showing details of pseudospines.

anterior margin of "horn." Slightly flatter posterior eyes arising from very prominent, well-sclerotized lateral tubercles which face more or less posteriorly. Eyes in most specimens separated about one ocular diameter as measured from corneal margin of each eye.

Illustrations of general form of coxal area by Chamberlin (1936, Pl. F; 1931, fig. 63) here augmented by scan electron micograph (Fig. 9). In addition to the usual apical, marginal and discal setae, a series of 5-7 setae (Fig. 16) is located on median border of maxilla which intergrades with apical setae (included in apical setal number in chaetotaxal formulae). Each coxa I with group of elongate pseudospines, separated from posterior margin of coxa by at least one spine length (Figs. 20, 22, 25, 31).

Obovate abdomen (Figs. 8, 32) broadest at segment 6, with 10 visible tergites dorsally, each bearing numerous, inconspicuous, minute setae. Sclerotic shield formed by fused 11th tergite and sternite (Chamberlin 1931, figs. 63, 64) surrounding 12th or anal segment. Scuta of tergites 1-8 and sternites 5-10 divided. Lateral margins of the broad tergites project beyond the narrower sternites producing shield-like dorsum. Well-sclerotized pair of apodemes on anterior margins of sternites 4 and 5. Tessellated pleural membranes with 3 prominent, longitudinal, sinuate furrows which extend entire length of abdomen (Fig. 19). Well-developed pleurite bearing internal apodeme, characteristic of pseudogarypids, at anterior end of ventral furrow. Males may bear longitudinal series of additional slightly sclerotic, or frequently only pigmented, "plates" in all 3 furrows; females lack these supplemental structures. External genitalia of both sexes with no apparent unique features. Internal and external male genital structures of *P. bicornis* (Chamberlin 1931, fig. 51) apparently characteristic of genus. Setal distribution on sternites 3 and 4 of both sexes, as illustrated by Jacot (1938:302), appears representative of the genus.

Chelicerae (Chamberlin 1923, Pl. F; 1931, fig. 14) very small, largely hidden from dorsal view by carapace (fig. 13). Proximal portion of hand smooth, lightly sclerotized; distal portion well-sclerotized, deeply pigmented, tessellated, with 8-12 simple setae. Flagellum of 2 slender, curved, simple setae, typical of family. Movable finger with typical subapical lobe, small and conspicuously pigmented; anterior medial margin of



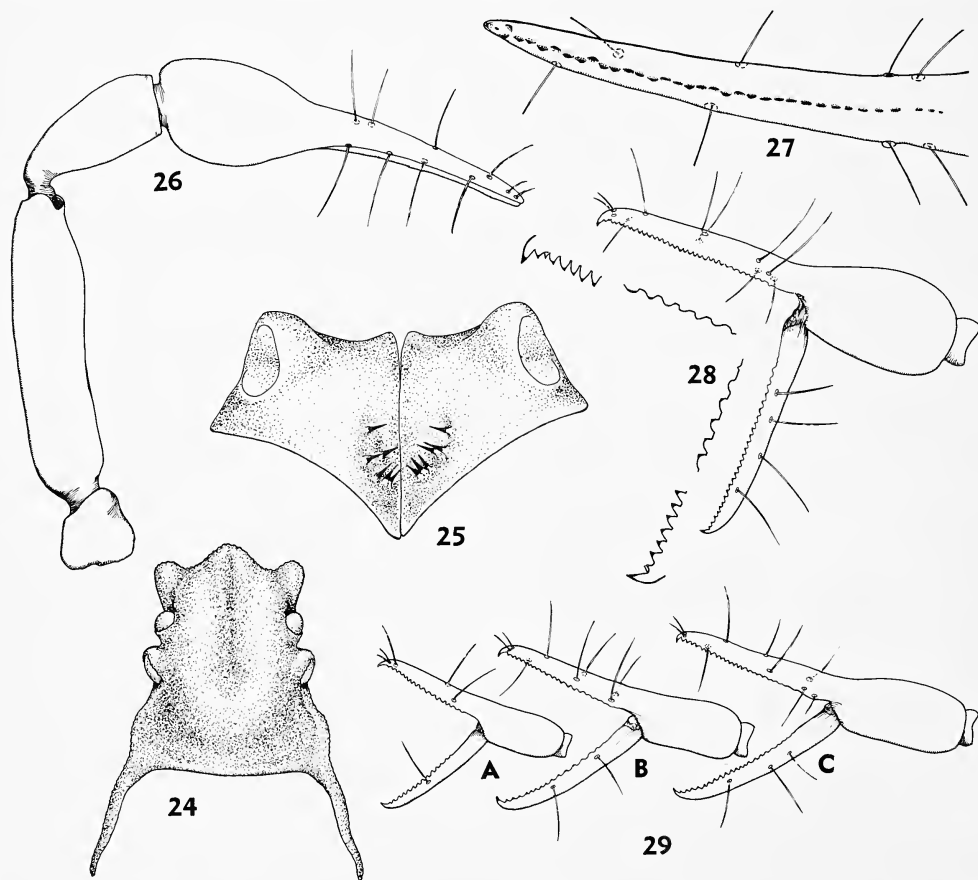
Figs. 21-23.—*Pseudogarypus bicornis* (Banks): 21, carapace; 22, coxae I showing details of pseudospines; 23, external aspect of chela of male showing details of teeth (cotype WM-621.01001).

finger with 1-2 very small to obsolete "microdenticles" or serrulations; serrula exterior fused along entire length to movable finger with sharply differentiated acute terminal tooth or blade directed at an anterior angle from remaining 15-16 blades. Fixed finger, characteristic of family, lacking all teeth except terminal or apical one; serrula interior a broad plate-like sheet of fused blades.

Pedipalps (Chamberlin 1923, Pl. V; Hoff 1926, fig. 5) long, slender and typical of family; fingers of chela relatively straight. Marginal teeth somewhat staggered instead of aligned in straight row (Fig. 27), erroneously appearing heterodentate in some orientations. One or 2 internal accessory teeth near tooth 1 of each finger. Chelal chaetotaxy typical of family (Figs. 15, 23, 28, 29, 30).

Legs illustrated by Chamberlin (1923, figs. 1, 8; fig. 63) typical of family.

Remarks.—In this genus, many of the characteristics traditionally employed for discrimination of species cannot be used in identifying individual specimens due to the degree of both inter- and intra-specific variability. For example, the position and number of tactile setae on the chelal fingers are too inconstant to be useful as identifying characteristics. In both *P. banksi* and *P. hesperus*, ST tends to be closer to SB, while in *P.*



Figs. 24-29.—*Pseudogarypus hesperus* Chamberlin: 24, carapace; 25, coxae I showing details of pseudospines (paratype JC-708.01001); 26, dorsal aspect of palp of female; 27, fixed finger of chela from ventral view showing tooth arrangement and tactile setae; 28, external aspect of chela of female showing details of teeth; 29, comparative development of chela: a—protonymph, b—deutonymph, c—tritonymph.

bicornis and *P. spelaeus* ST tends to be closer to T. The exceptions to this pattern are evident in the arrangement observed in 46 otherwise typical males of *P. bicornis*: ST in one male is 0.24 of the distance from T to SB; in 42 males it is between 0.30 and 0.47 of the distance; and in three, it is 0.50 to 0.56 of the distance. Further, two males and one female of *P. bicornis* and one male of *P. hesperus* with genitalia typical of adults have only three setae on the movable finger. The arrangement and number of pseudospines provide other examples of variability. The pseudospines in *P. banksi* tend to be in a line while in other species they are in a scattered cluster. Although mean spine number per coxa is slightly greater in both *P. spelaeus* and *P. banksi* than in the other two species, ranges overlap. When all specimens studied were arranged according to the depth of the notches on the anterior carapacial margin, it became apparent that with certain exceptions, the notches were progressively deeper in the following sequence of species: *P. banksi*, *P. hesperus*, *P. bicornis*, and *P. spelaeus* (Figs. 4-7). Further, whereas the femoral length is nearly equal in *P. hesperus* and *P. banksi*, the chela tends to be slightly longer in *P. banksi*. Although these species are variable, they do appear to be "good" morphological species, and are separable by the combination of characters in the following key:

Key to Adults of the North American Species of *Pseudogarypus*

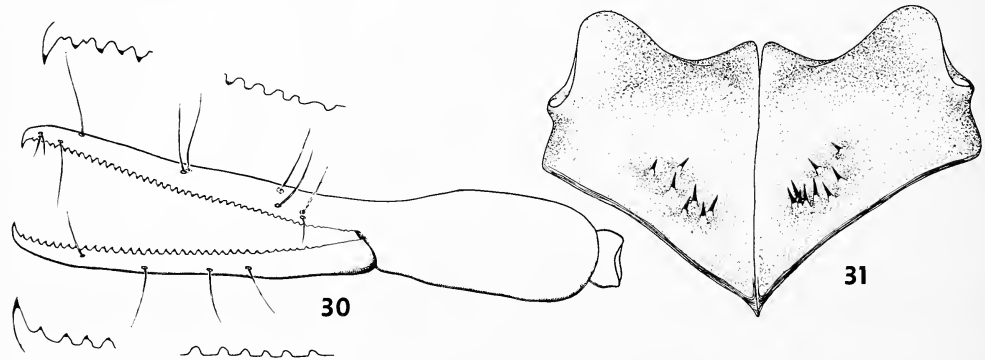
- 1. Chelal length (including pedicel) less than 1.70 mm 2
Chelal length (including pedicel) of male 1.87-1.90 mm, of female 1.99 mm; palpal femur length of male 1.65 mm, of female 1.73 mm; cavernicolous, Samwell Cave, California *P. spelaeus*, new species
- 2. Palpal femur length of male less than 1.0 mm, of female less than 1.05 mm; anterior margin of carapace with shallow notch between antero-lateral and median protuberances (Figs. 4, 5) 3
Palpal femur length of male 1.02-1.28 mm, of female 1.07-1.33 mm; chelal length of male 1.27-1.51 mm, of female 1.31-1.61 mm; anterior margin of carapace with relatively deep notch between antero-lateral and median protuberances (Fig. 6); chelal fingers with widely-spaced teeth; epigean, widely-distributed in western United States *P. bicornis* (Banks)
- 3. Teeth in distal half of chelal fixed finger definitely separated (Fig. 15), not appearing contiguous; chelal length of male (including pedicel) 1.19-1.29 mm, of female 1.20-1.31 mm; palpal femur length of male 0.90-0.98 mm, of female 0.96-1.02 mm; epigean, from the United States and Canada . . . *P. banksi* Jacot
Teeth in distal half of chelal fixed finger appearing contiguous in male and only very slightly spaced in female (Fig. 28); chelal length (including pedicel) of male 1.07-1.18 mm, of female 1.09-1.24 mm; palpal femur length of male 0.85-0.97 mm, of female 0.91-1.03 mm; epigean, from the Pacific Northwest of the United States *P. hesperus* Chamberlin

Even though *P. hesperus* and *P. banksi* share a number of traits in common they appear to be geographically isolated. On the other hand, *P. bicornis* and *P. hesperus*, markedly different in their expressions of several characters, are sympatric in Oregon, and even may have been collected together from under the same rock. *P. spelaeus*, most similar to the epigean species *P. bicornis*, apparently exhibits a certain degree of cavern-

icolous adaptation. *P. spelaeus* (Table 6) is much larger than the other three species, *P. bicornis* (Table 3) is next in size, while *P. banksi* (Table 2) and *P. hesperus* (Table 5) are generally smaller. The chelal teeth of both *P. bicornis* and *P. spelaeus* are widely spaced, those of *P. banksi* moderately spaced, while the teeth of *P. hesperus* are contiguous on the distal half of the fixed finger, especially of the male.

Table 1.—Appendicular morphometric ratios of adult *Pseudogarypus* Ellingsen (abbreviations: B-breadth, D-depth, L-length).

	<i>P. banksi</i> Jacot		<i>P. hesperus</i> Chamberlin	
	♂ ♂ (n=14)	♀ ♀ (n=13)	♂ ♂ (n=14)	♀ ♀ (n=15)
Pedipalp				
Trochanter L/B	1.3-1.5	1.2-1.7	1.4-1.6	1.4-1.6
Femur L/B	4.6-5.0	4.3-5.0	4.3-4.8	4.4-4.9
Tibia L/B	2.5-2.9	2.4-2.7	2.4-2.8	2.5-2.7
Chela (with pedicel) L/B	4.2-4.7	4.0-4.4	4.1-4.5	3.8-4.2
Chela (with pedicel) L/D	4.6-5.1	4.4-4.8	4.4-4.8	4.3-4.9
Movable finger L/Hand L	1.5-1.7	1.5-1.7	1.4-1.8	1.4-1.7
Hand L/D	1.6-1.8	1.4-1.8	1.5-1.7	1.5-1.7
Chela L/Femur L	1.21-1.32	1.24-1.35	1.18-1.26	1.16-1.23
Leg I				
Basifemur L/D	2.8-3.4	2.8-3.1	2.9-3.3	2.8-3.2
Telfemur L/D	2.6-3.0	2.4-2.9	2.6-3.2	2.7-3.0
Tibia L/D	2.8-3.1	2.9-3.2	3.1-3.7	2.8-3.3
Tarsus L/D	6.6-7.2	6.6-7.7	6.1-7.7	6.1-7.2
Leg IV				
Basifemur L/D	2.2-2.6	2.1-2.5	2.3-2.8	2.7-2.9
Telfemur L/D	3.2-3.5	3.0-3.5	2.7-3.4	2.7-3.2
Tibia L/D	4.9-5.6	5.0-5.8	5.2-6.1	5.3-6.5
Tarsus L/D	8.4-9.7	8.3-9.8	9.1-10.2	9.2-9.9



Figs. 30-31.—*Pseudogarypus spelaeus*, new species: 30, external aspect of chela of male showing details of teeth (holotype DM-407.01001); 31, coxae I showing details of pseudospines (paratype DM-405.01001).

Table 2.—Appendicular morphometric ratios of adult *Pseudogarypus* Ellingsen (abbreviations: B-breadth, D-depth, L-length, ?-indeterminable).

<i>P. bicornis</i>	<i>P. bicornis</i> (Banks)		<i>P. spelaeus</i> , n. sp.	
	♂ ♂ (n=52)	♀ ♀ (n=30)	♂ ♂ (n=2)	♀ (n=1)
Pedipalp				
Trochanter L/B	1.3-1.6	1.4-1.6	1.6,1.6	1.6
Femur L/B	4.7-6.2	5.1-6.0	7.3,6.5	7.0
Tibia L/B	2.5-3.0	2.5-3.3	3.0,3.5	3.6
Chela (with pedicel) L/B	4.2-5.5	4.1-5.0	5.4,5.4	5.4
Chela (with pedicel) L/D	4.6-5.7	4.4-5.4	5.9,5.8	5.9
Movable finger L/Hand L	1.5-1.8	1.4-1.7	1.7,1.6	1.7
Hand L/D	1.6-2.1	1.6-2.0	2.2,2.2	2.1
Chela L/Femur L	1.12-1.28	1.16-1.26	1.09,1.13	1.14
Leg I				
Basifemur L/D	2.8-3.6	3.0-3.6	4.2, ?	4.7
Telofemur L/D	2.6-3.2	2.6-3.4	3.5,3.8	4.1
Tibia L/D	3.1-3.8	3.1-3.8	4.2,4.2	4.6
Tarsus L/D	7.0-8.7	7.1-8.8	10.5,11.4	11.7
Leg IV				
Basifemur L/D	2.3-2.9	2.3-3.3	3.0,3.2	3.1
Telofemur L/D	2.7-3.6	2.8-3.6	4.0,4.4	4.2
Tibia L/D	5.9-6.6	5.7-7.2	8.6,8.4	8.7
Tarsus L/D	10.0-12.3	10.0-11.7	13.5,13.9	14.2

Table 3.—Measurements (in mm) of *Pseudogarypus banksi* Jacot adults (abbreviations: B-breadth, D-depth, L-length).

	♂ ♂ (n=14)	♀ ♀ (n=13)
Body L	2.27-2.40	2.34-2.55
Abdominal B	1.37-1.67	1.54-1.65
Carapace L	0.54-0.60	0.55-0.64
Ocular B	0.32-0.34	0.33-0.36
Posterior B	0.44±-0.54±	0.55±
Ant. eye diam.	0.062-0.068	0.062-0.074
Post. eye diam.	0.062-0.080	0.068-0.086
Chelicera L/B	0.23-0.24/0.13-0.14	0.23-0.26/0.14-0.15
Pedipalps		
Trochanter L/B	0.28-0.32/0.21-0.22	0.33/0.22-0.23
Femur L/B	0.90-0.98/0.19-0.21	0.96-1.02/0.20-0.22
Tibia L/B	0.48-0.54/0.19-0.20	0.48-0.55/0.20-0.21
Chela (inc. pedicel) L	1.19-1.29	1.20-1.31
Chela B	0.26-0.29	0.29-0.31
Chela D	0.23-0.26	0.27-0.28
Hand L	0.41-0.48	0.44-0.46
Movable finger L	0.69-0.76	0.76-0.79
Leg I		
Basifemur L/D	0.30-0.33/0.10-0.11	0.33-0.35/0.11-0.12
Telofemur L/D	0.30-0.32/0.10-1.12	0.31-0.34/0.11-0.13
Tibia L/D	0.25-0.29/0.08-0.09	0.27-0.30/0.08-0.10
Tarsus L/D	0.44-0.46/0.06-0.07	0.45-0.49/0.06-0.07
Leg IV		
Basifemur L/D	0.25-0.28/0.10-0.12	0.26-0.30/0.11-0.12
Telofemur L/D	0.39-0.43/0.12-0.13	0.42-0.48/0.13-0.14
Tibia L/D	0.45-0.50/0.08-0.09	0.48-0.52/0.08-0.10
Tarsus L/D	0.56-0.63/0.06-0.08	0.58-0.67/0.06-0.07

Pseudogarypus banksi Jacot

Figures 4, 8-10, 14-20

Pseudogarypus banksi Jacot 1938:302; Hoff 1958:18.*Pseudogarypus hesperus*: Manley 1969:7, 12 (misidentification, Michigan records).*Pseudogarypus* sp: Nelson 1975:283 (Michigan records).

To the present time, the only published record of *P. banksi* is the type collection described by Jacot from New Hampshire. Our examination of several large series of specimens of the described species of *Pseudogarypus* from North America reveals that the Michigan specimens, reported as *P. hesperus* by Fenstermacher (1959) in his unpublished masters thesis and by Manley (1969), are rightfully assignable to *P. banksi*, not only from geographical, but also from morphological evidence. The two species, although similar in general size and conformation, can be distinguished by the characters in the key. The following redescription of *P. banksi*, including all nymphal stages, is based upon examination of the type series and more than 40 specimens from the eastern United States and Canada.

Diagnosis.—Body length of male 2.27-2.40 mm, of female 2.34-2.55 mm; palpal femur length of male 0.90-0.98 mm, of female 0.96-1.02 mm. Epigean species with moderately spaced marginal teeth on distal half of chela.

Description.—Measurements in Table 2.

ADULTS. Carapace (Fig. 18) only slightly longer than posterior breadth; notch between anterolateral and median protuberances relatively shallow (Figs. 4, 17d). Coxal area illustrated in Figs. 9, 20; each coxa I bears a somewhat linear array of 5 to 6 pseudospines (average about 7 for male, 6 for female). Abdomen broadly obovate (Fig. 8), only slightly longer than broad. Appendages typical of epigean species (morphometric ratios Table 1), pedipalp of male illustrated by Nelson (1975), of female (Fig. 14); chelal chaetotaxy and dentition illustrated in Fig. 15; fixed finger with a graded series of moderately spaced, retrorse, triangular marginal teeth (male 27-33, female 28-34) which are distally elongate, gradually becoming lower and broader basally; movable finger with entire series similar in general shape but lower and broader, very widely spaced basally (male with 24-27, female with 23-29 teeth).

TRITONYMPH. Similar to adult except as noted. Slightly paler and smaller; derm slightly less sclerotized. Anterior carapacial margin illustrated in Fig. 17c. Coxal chaetotaxy (WM-1146.01006) 6-3-9:0-0-3-PS:0-2-5:0-1-7:0-1-7, each coxa I with 4-7 pseudospines. Chaetotaxy of chela typical of species and nymphal stage; teeth of both fingers similar in shape to adult but more widely separated, fixed finger with 24-27, movable finger with 19-24 marginal teeth.

DEUTONYMPH. Similar to adult except as noted. Paler and smaller; derm definitely tessellated but much less sclerotized. Anterior carapacial margin illustrated in Fig. 17b. Coxal chaetotaxy (WM-1146.01007) 5-2-3:0-1-3-PS:0-2-3:0-2-3:0-1-3, each coxa I with 4-6 pseudospines. Chaetotaxy of chela typical of species and nymphal stage; teeth of both fingers similar in shape to adult but more widely spaced, fixed finger with 20-21, movable finger with 17-19 marginal teeth.

PROTONYMPH. Similar to adult except as noted. Much paler and smaller; derm definitely tessellated but weakly sclerotized. Anterior carapacial margin only slightly notched; median protuberance barely developed, two-parted (Fig. 17a); anterior eye tubercles lacking, posterior eye tubercles very weakly developed. Coxal chaetotaxy

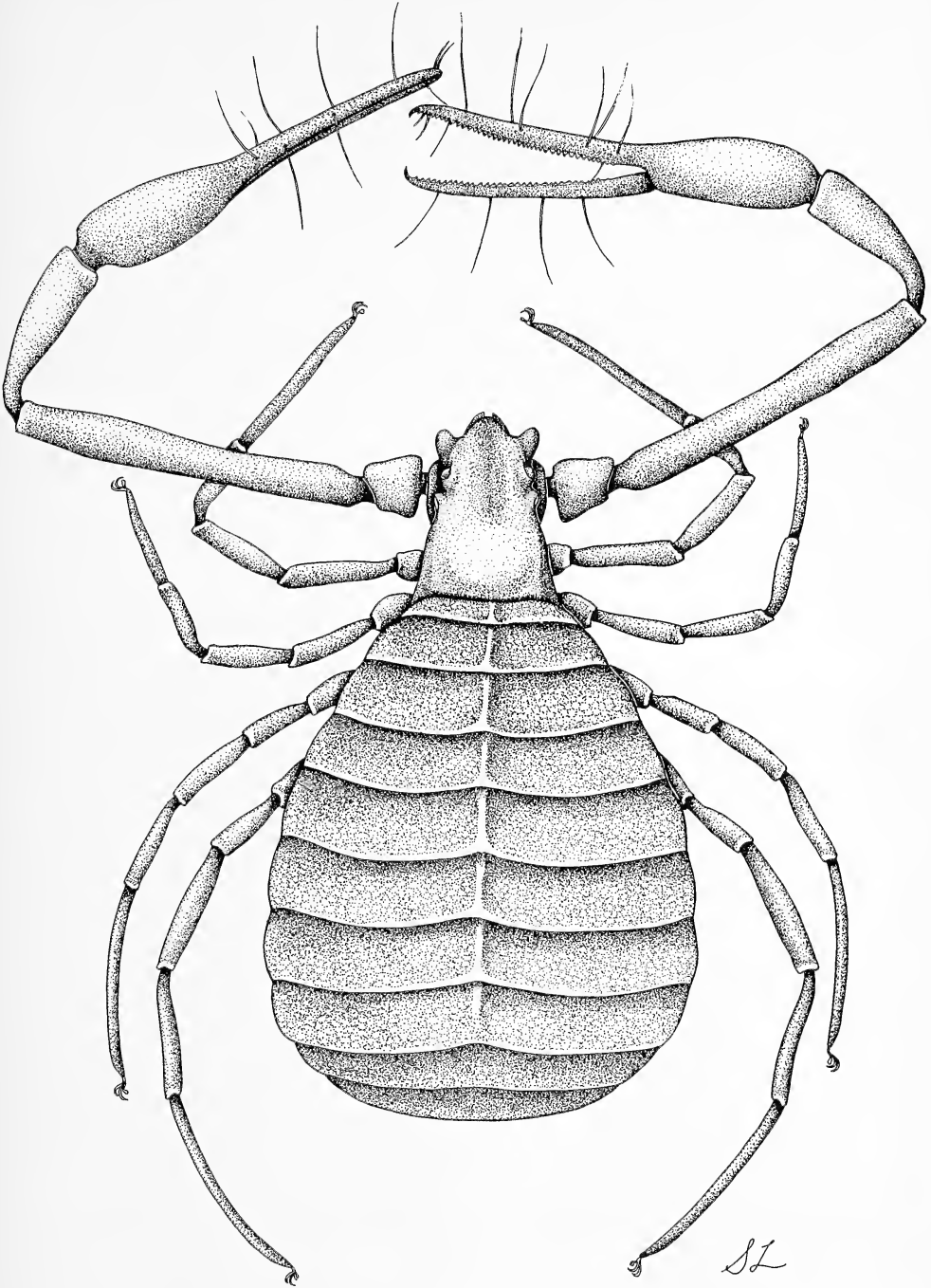


Fig. 32.—*Pseudogarypus spelaesus*, new species: dorsal view (holotype male).

(WM-1146.01001) 2-0-2:0-0-1-PS:0-0-1:0-0-1:0-0-1, median marginal series lacking, each coxa I with 3-5 pseudospines. Chaetotaxy of chela typical of species and nymphal stage; teeth of both fingers similar in shape to adult but very widely spaced, fixed finger with 14-19, movable finger with 11-16 marginal teeth.

Remarks.—In his reference to the carapace of *P. bicornis*, Jacot (1938:302) states that the “horns are deeply separated from the central lobe, so that there projects between them a rounded lobe but at a lower level. From the center of the lower lobes there springs a short but conspicuous bristle which extends forward to [the] level of the horns and central lobe.” We have searched in vain for this lower “rounded lobe” and its “conspicuous bristle.” In our opinion, Jacot must have been describing the chelicera since from a dorsal view of a mounted specimen of *Pseudogarypus* with attached chelicerae (Fig. 13), these diminutive structures appear as rounded lobes and the galea as conspicuous bristles. Additionally, Jacot illustrates the tip of a chelal finger showing a number of accessory teeth in addition to the marginal teeth (1938, fig. C). All of the chelae examined bear a single accessory tooth located near the first marginal tooth. Jacot may have seen and illustrated the bases of a series of small broken setae.

Distribution.—The known range of *Pseudogarypus banksi* apparently extends from Michigan eastward to the New England states and northward into southern Canada. Despite extensive collections by Hoff (1949) this species has not been recovered from Illinois. The present disjunct pattern of distribution will likely be eliminated when

Table 4.—Measurements (in mm) of *Pseudogarypus banksi* Jacot nymphs (abbreviations: B-breadth, D-depth, L-length).

	Tritonymph (n=7)	Deutonymph (n=3)	Protonymph (n=6)
Body L	1.64-1.86	1.48-1.65	1.08-1.23
Abdominal B	1.08-1.25	0.98-1.04±	0.69-0.79
Carapace L	0.46-0.51	0.39-0.43	0.30-0.35
Ocular B	0.30-0.32	0.28-0.30	0.25-0.28
Posterior B	0.44±-0.48±	0.41±-0.44±	0.40±
Ant. eye diam.	0.049-0.058	0.043-0.049	0.040-0.046
Post. eye diam.	0.062-0.065	0.037-0.043	0.037-0.046
Chelicera L/B	0.20-0.22/0.12-0.13	0.18-1.20/0.11	0.16-1.18/0.09-0.11
Pedipalps			
Trochanter L/B	0.26-0.28/0.16-0.19	0.21-0.23/0.14-0.16	0.15-0.21/0.11-0.13
Femur L/B	0.70-0.78/0.15-0.17	0.59-0.63/0.13-0.16	0.42-0.49/0.11-0.12
Tibia L/B	0.39-0.43/0.16-0.17	0.33-0.35/0.14-0.15	0.25-0.29/0.11-0.13
Chela (inc. pedicel) L	0.93-1.04	0.83-0.89	0.66-0.70
Chela B	0.20-0.22	0.18-0.19	0.13-0.16
Chela D	0.18-0.21	0.17-0.18	0.13-0.15
Hand L	0.33-0.40	0.30-0.33	0.21-0.26
Movable finger L	0.56-0.62	0.50-0.54	0.39-0.42
Leg I			
Basifemur L/D	0.23-0.27/0.09-0.10	0.21-0.23/0.08-0.09	0.16-0.18/0.06-0.07
Telofemur L/D	0.23-0.28/0.09-0.10	0.19-0.21/0.08-0.09	0.13-0.16/0.07-0.08
Tibia L/D	0.21-0.23/0.07-0.08	0.17-0.18/0.07-0.08	0.13-0.14/0.06-0.07
Tarsus L/D	0.33-0.38/0.06-0.07	0.28-0.32/0.06-0.07	0.23-0.24/0.05-0.06
Leg IV			
Basifemur L/D	0.21-0.22/0.09-0.11	0.15-0.17/0.08-0.09	0.12-0.14/0.07-0.08
Telofemur L/D	0.31-0.35/0.10-0.12	0.26-0.28/0.09-0.10	0.19-0.22/0.08-0.09
Tibia L/D	0.30-0.40/0.07-0.08	0.28-0.31/0.07-0.08	0.20-0.24/0.06-0.07
Tarsus L/D	0.45-0.51/0.06-0.07	0.36-0.41/0.0600-0.07	0.30-0.32/0.05-0.06

Muchmore (pers. comm.) publishes additional records and habitat data for *P. banksi* collected from numerous localities in the eastern United States.

Specimens examined.—CANADA: *Quebec*; Gatineau Park, Harrington Lake, 20 June 1954 (R. McCondochie), 2 females (WBM). UNITED STATES: *Michigan*; Chippewa Co., T46N, R6W, s31, 26 August 1969 (S. O. Nelson, Jr.), 3 males, 1 female (WBM); *New Hampshire*; Grafton Co., Pierce Bridge, 29 August (year unknown) (A. P. Jacot), 1 male, 4 females, 3 nymphs (MCZ), 0.9 mi W of Gale River, 25 June 1967 (W. B. Muchmore), 2 males, 2 females, 6 nymphs (WBM); *New York*; Albany Co., Rensselaerville, E. M. Huyck Preserve, 3 September 1955 (W. B. Muchmore), 6 males, 5 females, 9 nymphs (WBM), 10 September 1955 (W. B. Muchmore), 2 males, 1 female (WBM), 27 August 1966 (W. B. Muchmore), 2 males (WBM); *Essex Co.*, Wilmington Notch, 1 July 1967 (W. B. Muchmore), 1 male (WBM), about 5 mi SW of Wilmington, 1 July 1967 (W. B. Muchmore), 1 female, 1 nymph (WBM); *Hamilton Co.*, 1.5 mi NW of Long Lake, 1 July 1967 (W. B. Muchmore), 1 female (WBM).

Pseudogarypus bicornis (Banks)
Figures 6, 11, 21-23

Garypus bicornis Banks 1895:8.
Pseudogarypus bicornis: Ellingsen 1909:217; Banks 1911:637; Chamberlin 1923:162 (22 figs.), 1931:232; Beier 1932:57; Jacot 1938:301; Hoff 1946:198, 1961:443.
Cerogarypus agassizi Jacot 1938:301; Hoff 1958:18. NEW SYNONYMY.

Table 5.—Measurements (in mm) of *Pseudogarypus bicornis* (Banks) adults (abbreviations: B-breadth, D-depth, L-length).

	♂ ♂ (n=52)	♀ ♀ (n=30)
Body L	2.23-2.96	2.61-3.25
Abdominal B	1.44-1.77	1.64-1.97
Carapace L	0.57-0.68	0.59-0.74
Ocular B	0.33-0.39	0.34-0.39
Posterior B	0.40±-0.55±	0.51±-0.57±
Ant. eye diam.	0.062-0.086	0.074-0.089
Post. eye diam.	0.062-0.086	0.068-0.089
Chelicera L/B	0.24-0.27/0.13-0.15	0.23-0.29/0.13-0.16
Pedipalps		
Trochanter L/B	0.31-0.36/0.21-0.25	0.33-0.40/0.21-0.26
Femur L/B	1.02-1.28/0.18-0.22	1.07-1.33/0.19-0.23
Tibia L/B	0.50-0.63/0.18-0.22	0.52-0.72/0.19-0.23
Chela (inc. pedicel) L	1.27-1.51	1.31-1.61
Chela B	0.26-0.34	0.28-0.39
Chela D	0.24-0.31	0.26-0.36
Hand L	0.43-0.58	0.47-0.63
Movable finger L	0.74-0.89	0.79-0.94
Leg I		
Basifemur L/D	0.32-0.42/0.10-0.14	0.37-0.43/0.11-0.13
Telofofur L/D	0.31-0.38/0.09-0.13	0.33-0.40/0.11-0.14
Tibia L/D	0.28-0.33/0.08-0.10	0.29-0.36/0.08-0.11
Tarsus L/D	0.45-0.57/0.06-0.07	0.47-0.56/0.06-0.08
Leg IV		
Basifemur L/D	0.27-0.34/0.10-0.15	0.29-0.37/0.10-0.14
Telofofur L/D	0.40-0.51/0.12-0.18	0.44-0.55/0.13-0.18
Tibia L/D	0.50-0.60/0.08-0.13	0.53-0.67/0.08-0.11
Tarsus L/D	0.61-0.75/0.06-0.07	0.60-0.80/0.06-0.07

As noted previously, Chamberlin as early as 1923 described *P. bicornis* in detail from a single non-type male. Hoff (1946) restudied the type series of *P. bicornis*, designated a lectotype (male, USNM 4191) and published a detailed description of a male and a tritonymph. In 1961, he supplemented this description with measurements of a single male collected in Colorado. Since *P. bicornis* has been known only from three or four males and a tritonymph, and since there has been so much confusion as to which specimens rightfully belong to this species, it is appropriate to provide a full description of all stages and give data relative to intraspecific variation.

Diagnosis.—Body length of male 2.23-2.96 mm, of female 2.61-3.25 mm; palpal femur length of male 1.02-1.28 mm, of female 1.07-1.33 mm; epigean species with widely spaced marginal teeth on chela.

Description.—Measurements in Tables 5-7.

ADULTS. Carapace (Fig. 21) only slightly longer than posterior breadth; notch between anterolateral and median protuberances relatively deep (Fig. 6). Each coxa I bears a cluster (Fig. 22) of 4-7 scattered pseudospines (average about 5). Abdomen broadly obovate, only slightly longer than broad. Appendages typical of epigean species (morphometric ratios Table 2), pedipalp of male illustrated by Hoff (1946, fig. 5); chelal chaetotaxy and dentition illustrated in Figs. 11, 23; fixed finger with a graded series of widely spaced, elongate marginal teeth (male 32-43, female 34-42) which are distally elongate, gradually becoming lower, broader and more widely spaced basally (tooth shape

Table 6.—Measurements (in mm) of *Pseudogarypus bicornis* (Banks) nymphs (abbreviations: B-breadth, D-depth, L-length).

	Tritonymphs (n=7)	Deutonymphs (n=3)	Protonymphs (n=6)
Body L	205-2.27	1.48-1.84	1.24-1.43
Abdominal B	1.14-1.53	1.18-1.28	0.80-0.93
Carapace L	0.51-0.57	0.46-0.48	0.31-0.35
Ocular B	0.33-0.35	0.28-0.33	0.26-0.27
Posterior B	0.44±0.51±	0.47±0.49±	0.38±0.44±
Ant. eye diam.	0.056-0.068	0.043-0.056	0.037-0.043
Post. eye diam.	0.062-0.074	0.040-0.056	0.030-0.043
Chelicera L/B	0.21-0.23/0.12-0.16	0.18-0.19/0.11-0.12	0.16-0.18/0.09-0.10
Pedipalps			
Trochanter L/B	0.28-0.31/0.19-0.21	0.24-0.27/0.13-0.15	0.20-0.21/0.11-0.13
Femur L/B	0.85-0.93/0.17-0.20	0.68-0.78/0.14-0.16	0.52-0.59/0.11-0.12
Tibia L/B	0.39-0.47/0.16-0.18	0.35-0.39/0.14-0.16	0.27-0.31/0.12-0.13
Chela (inc. pedicel) L	1.11-1.19	0.91-1.03	0.75-0.86
Chela B	0.21-0.25	0.18-0.19	0.16-0.17
Chela D	0.21-0.24	0.17-0.19	0.15-0.16
Hand L	0.42-0.43	0.31-0.37	0.25-0.29
Movable finger L	0.65-0.69	0.55-0.62	0.46-0.52
Leg I			
Basifemur L/D	0.29-0.30/0.09-0.10	0.20-0.24/0.07-0.08	0.17-0.19/0.06-0.07
Teloferum L/D	0.26-0.29/0.09-0.11	0.20-0.22/0.08-0.09	0.15-0.17/0.07-0.08
Tibia L/D	0.22-0.26/0.07-0.09	0.16-0.18/0.06-0.07	0.14-0.16/0.06-0.07
Tarsus L/D	0.39-0.41/0.05-0.07	0.31-0.32/0.05-0.06	0.25-0.28/0.05-0.06
Leg IV			
Basifemur L/D	0.20-0.25/0.09-0.10	0.17-0.18/0.08-0.09	0.11-0.15/0.07-0.08
Teloferum L/D	0.33-0.37/0.12-0.13	0.27-0.29/0.09-0.10	0.21-0.25/0.08-0.09
Tibia L/D	0.40-0.45/0.08-0.09	0.32-0.33/0.06-0.07	0.24-0.27/0.06-0.07
Tarsus L/D	0.51-0.59/0.05-0.07	0.43-0.44/0.05-0.06	0.35-0.37/0.05-0.06

varies from specimen to specimen from retrorse triangular to nearly parallel-sided); movable finger with entire series similar in general shape but lower, broader, and very widely spaced basally (male 27-36, female 27-34 teeth).

TRITONYMPH. Similar to adult except as noted. Slightly paler and smaller; derm slightly less sclerotized. Coxal chaetotaxy 6-3-7:0-0-6-PS:0-1-6:0-1-6:0-1-6, each coxa I with 4-5 pseudospines. Chaetotaxy of chela typical of species and nymphal stage. Teeth of both fingers similar in shape to adult but more widely spaced in certain specimens, fixed finger with 26-34, movable finger with 24-28 marginal teeth.

DEUTONYMPH. Similar to adult except as noted. Paler and smaller; derm definitely tessellated but much less sclerotized. Coxal chaetotaxy 5-1-6:0-0-3-PS:0-1-3:0-1-3:0-2-3, each coxa I with 3 pseudospines. Chaetotaxy of chela typical of species and nymphal stage. Teeth of both fingers similar in shape to adult but more widely spaced in certain specimens, fixed finger with 24-27, movable finger with 22-25 marginal teeth.

PROTONYMPH. Similar to adult except as noted. Much paler and smaller; derm definitely tessellated but weakly sclerotized. Anterior carapacial margin much less deeply notched; median protuberance barely developed and two-parted; anterior eye tubercles lacking, posterior eye tubercles weakly developed and much less sclerotized. Coxal chaetotaxy 2-0-2:0-1-1-PS:0-1-0:0-0-1:0-0-1, median marginal series lacking, each coxa I with 2-3 pseudospines. Chaetotaxy of chela typical of species and nymphal stage. Teeth

Table 7.—Measurements (in mm) of *Pseudogarypus biconis* (Banks) adults bearing only three tactile setae on chelal movable finger (abbreviations: B-breadth, D-depth, L-length, ?-indeterminable. "Atypical" measurements followed by an asterisk).

	♂ ♂		♀
	Cotype	JC-1317.02003	EB-1363.01001
Body L	2.22*	2.56	212*
Abdominal B	±1.28*	?	1.25*
Carapace L	0.57	0.66	0.60
Ocular B	0.32*	0.34	0.39
Posterior B	±0.53	0.51±	0.51±
Ant. eye diam.	0.056*	0.077	0.074
Post. eye diam.	0.049*	0.074	0.080
Chelicera L/B	??	0.24/0.13	0.24/0.13
Pedipalps			
Trochanter L/B	?/0.18*	??	0.33/0.21
Femur L/B	0.86*/0.17*	1.08/0.20	0.98*/0.21
Tibia L/B	0.44*/0.17*	0.51/0.20	0.49*/0.18*
Chela (inc. pedicel) L	1.12*	1.30	1.28*
Chela B	0.24*	0.29	?
Chela D	0.21*	0.27	0.24*
Hand L	0.39*	0.48	0.48
Movable finger L	0.69*	0.75	0.76*
Leg I			
Basifemur L/D	0.31*/0.09*	0.37/0.11	0.28*/0.10*
Telfemur L/D	0.27*/0.09	0.34/0.12	0.29*/0.11
Tibia L/D	0.24*/0.07*	0.29/0.10	0.22*/0.08
Tarsus L/D	0.43*/0.06	0.49/0.07	0.39*/0.07
Leg IV			
Basifemur L/D	0.24*/0.09*	0.29/0.11	0.23*/0.10
Telfemur L/D	0.34*/0.11*	0.43/0.13	0.37*/0.12*
Tibia L/D	0.48*/0.07*	0.54/0.13	0.43*/0.09
Tarsus L/D	0.53*/0.06	0.68/0.06	0.57*/0.07

of both fingers similar in shape to adult but very widely separated, fixed finger with 19-24, movable finger with 17-21 marginal teeth.

Remarks.—It should be emphasized that the species in the genus *Pseudogarypus* appear to be highly variable and, therefore, the description of a new species from one or two specimens must be approached with great caution. Initially the authors considered the possibility that the Oregon specimens of *P. bicornis* might be two species due to size and slight differences in the shape of the chelal teeth. When specimens from approximately 50 localities in seven states were examined and measured it became obvious that intermediates existed for every character and that no group of specimens possessed the same cluster of traits. It is true that in certain localities there are local populations with limited variation in one or two characters; e.g., Utah and Wyoming specimens are at the lower limits of the size range while San Benito County, California, and certain Oregon specimens are at the upper limits. However, when all of the specimens are taken together they form a continuum of variation leading to the conclusion that they are assignable to a single species. From studies based on large series of specimens (Benedict and Malcolm 1970, 1977; Chamberlin 1952), like this one of *P. bicornis*, it has become increasingly evident that intraspecific variation in some pseudoscorpion species is greater than had been thought in earlier years.

Three specimens of this species which possess typical adult genitalia bear only three tactile setae on the chelal movable finger. These specimens also tend to be smaller in a

Table 8.—Measurements (in mm) of *Pseudogarypus hesperus* Chamberlin adults (abbreviations: B—breadth, D—depth, L—length).

	♂ ♂ (n=14)	♀ ♀ (n=15)
Body L	2.32-2.66	2.40-2.85
Abdominal B	1.44-1.73	1.63-1.92
Carapace L	0.47-0.57	0.54-0.63
Ocular B	0.32-0.33	0.33-0.38
Posterior B	0.47±-0.57±	0.58±-0.57±
Ant. eye diam.	0.062-0.074	0.062-0.074
Post. eye diam.	0.068-0.086	0.074-0.093
Chelicera L/B	0.22-0.25/0.12-0.14	0.24-0.27/0.14-0.15
Pedipalps		
Trochanter L/B	0.30-0.33/0.20-0.22	0.33-0.35/0.21-0.24
Femur L/B	0.85-0.97/0.19-0.22	0.91-1.03/0.20-0.24
Tibia L/B	0.49-0.57/0.19-0.21	0.52-0.56/0.20-0.23
Chela (inc. pedicel) L	1.07-1.18	1.09-1.24
Chela B	0.26-0.28	0.26-0.31
Chela D	0.23-0.26	0.24-0.29
Hand L	0.39-0.47	0.44-0.45
Movable finger L	0.62-0.69	0.64-0.74
Leg I		
Basifemur L/D	0.31-0.35/0.10-0.11	0.31-0.35/0.12-0.13
Teloferum L/D	0.30-0.34/0.10-0.12	0.32-0.34/0.11-0.12
Tibia L/D	0.26-0.30/0.07-0.09	0.27-0.31/0.09-0.10
Tarsus L/D	0.40-0.48/0.06-0.07	0.42-0.49/0.06-0.07
Leg IV		
Basifemur L/D	0.27-0.32/0.10-0.11	0.30-0.33/0.11-0.12
Teloferum L/D	0.40-0.44/0.12-0.15	0.41-0.47/0.14-0.16
Tibia L/D	0.46-0.53/0.08-0.10	0.61-0.68/0.08-0.10
Tarsus L/D	0.56-0.65/0.06-0.07	0.59-0.69/0.06-0.07

number of measurements (Table 7). It is possible that these specimens may be neotenic adults, but neoteny in pseudoscorpions has not been clearly established, and, therefore, we feel it to be unwise to include the morphometric data of these specimens in Table 5 with the adults bearing the typical four setae on the movable finger.

Examination reveals no significant differences between male co-types of *P. bicornis* and the male holotype of *C. agassizi*. The existence of pseudospines on coxae I and the degree of sclerotization over the posterior eyes have already been discussed. Subtle differences, such as chelal tooth number and the slight size variation, follow the common range of continuous intraspecific variation exhibited by the extensive series of specimens of *P. bicornis* examined. In our opinion, therefore, the species are synonymous.

Habitats.—This species has been collected in the foothills and mountains at elevations from 300 to 3050 m and appears to inhabit most available surfaces including leaf litter, moss, bark and hollows of both living and dead trees and stumps, rock crevices and a "swallow's nest."

Specimens examined.—UNITED STATES: *Wyoming*; Yellowstone National Park, Specimen Ridge, 12 August 1891 (H. G. Hubbard and Swartz), 3 males, 4 nymphs (syntypes USNM, MCZ). Muchmore (pers. comm.) prepared slides of MCZ syntypes which are the types we examined. *Arizona*; Coconino Co., 15 mi N of Flagstaff, 16 August 1968 (R. H. Russell), 2 females (WBM); *California*; Los Angeles Co., 13.4 mi W of Big Pines, 8 September 1957 (unknown), 2 males, 2 females (WBM); San Benito Co., Pinnacles National Monument, 3 July 1958 (W. Gertsch and V. Roth), 2 males (WBM); *Colorado*; El Paso Co., North Cheyenne Canyon, 27 June 1962 (W. B. Muchmore), 3 males, 2 females (WBM), 29 June 1962 (W. B. Muchmore), 1 male (WBM); Park Co., 2 mi N of Fairplay, 29 August 1961 (W. Gertsch and W. Ivie), 1 female (WBM); *Idaho*; Bear Lake Co., Fish Haven, Bear Lake, 18 August 1923 (B. C. Cain), 1 female, 1 nymph (JCC); Blaine Co., 8-9 mi W of Ketchum (1890 m), 31 August 1941 (J. C. Chamberlin and D. E. Fox), 2 males, 2 females (JCC), 19 mi N of Ketchum (2075 m), 25 August 1941 (J. C. Chamberlin and R. L. Piemeisel), 2 males, 2 females (JCC); Franklin Co., Cub River Canyon, 26 June 1971 (G. F. Knowlton and Cazier), 1 male (WBM); *Oregon*; Douglas Co., 11 mi NE of Idleyld Park (335 m), 2 April 1972 (E. M. Benedict), 2 males, 6 nymphs (EMB), 65 mi E of Roseburg (1280 m), 22 June 1972 (E. M. Benedict), 1 nymph (EMB), 65 mi E of Roseburg (1770 m), 22 June 1972 (E. M. Benedict), 4 males, 1 female, 13 nymphs (EMB), 64 mi E of Roseburg (1280 m), 22 June 1972 (E. M. Benedict), 1 nymph (EMB), 9 mi S, 15 mi E of Steamboat (855 m), 21 October 1972 (E. M. Benedict), 1 male (EMB); 9 mi S, 14 mi E of Steamboat (945 m), 21 October 1972 (E. M. Benedict), 1 nymph (EMB), 12 mi E, 3 mi N of Tiller (520 m), 11 November 1972 (E. M. Benedict), 1 nymph (EMB), 2 mi E of Canyonville (305 m), 13 September 1973 (E. M. Benedict), 1 male (EMB), 8 mi S, 4 mi E of Tiller (795 m), 13 September 1973 (E. M. Benedict), 2 males, 1 female, 11 nymphs (EMB); Harney Co., 2 mi E of Frenchglen (1280 m), 19 March 1972 (E. M. Benedict), 1 male, 3 nymphs (EMB), 11 July 1972 (E. M. Benedict), 1 nymph (EMB), 18 March 1973 (E. M. Benedict), 1 nymph (EMB), 1 March 1974 (E. M. Benedict), 1 female (EMB), Blitzen Crossing on Steens Mt. (1525 m), 15 July 1971 (E. M. Benedict), 1 female (DRM), 31 July 1971 (E. M. Benedict and D. R. Malcolm), 1 male, 1 female (DRM), Big Indian Canyon on Steens Mt. (1675 m), 6 August 1971 (E. M. Benedict), 4 males, 1 female, 1 nymph (DRM), 25 July 1972 (E. M. Benedict), 1 male (EMB); Jackson Co., 9 mi S, 2 mi W of Ashland (2075 m), 17 September 1972 (E. M. Benedict), 1 nymph (EMB), 6 mi S, 12 mi W of Ashland (1465 m), 17 September 1972 (E. M. Benedict), 4 nymphs (EMB), 7 mi S, 13 mi E of Ashland (1495 m), 15 October 1972 (E. M. Benedict), 1 nymph (EMB), 7 mi S, 12 mi E of Ashland (1465 m), 15 October 1972 (E. M. Benedict), 1 male, 1 female (EMB), 4 mi S, 11 mi E of Ashland (1465 m), 15 October 1972 (E. M. Benedict), 1 female (EMB); Jefferson Co., Santiam Pass (1370 m), 3 September 1941 (J. C. Chamberlin), 2 males, 1 female (JCC), Ochoco Divide, 14 mi N, 23 mi E of Prineville (1525 m), 19 June 1972 (E. M. Benedict), 1 male, 1 female (EMB); Josephine Co., 4 mi NW of Oregon Cave National Monument (915 m), 10 August 1973 (E. M. Benedict), 1 nymph (EMB); Klamath Co., 12 mi N, 2 mi E of Lake of the Woods Resort (1770 m), 25 August 1972 (E. M. Benedict), 1 nymph, 0.5 mi N of Lake of the Woods Resort (1525 m), 14 October 1972 (E. M. Benedict), 2 nymphs (EMB); Lane Co., 2 mi N, 7 mi E of McKenzie Bridge (550 m), 28 February 1972 (E. M. Benedict), 1 male, 1 nymph (EMB), 13 mi S of Oakridge (550 m), 4 March 1972 (E. M. Benedict), 1 male (EMB), 5 mi E of McKenzie Bridge (520 m), 31 August 1973 (E. M. Benedict), 2 males (EMB); Linn Co., 5 mi E of McKenzie Bridge (610 m), 28 February 1972 (E. M. Benedict), 3

males, 2 females, 4 nymphs (EMB), 34 mi E of Sweet Home (975 m), 1 September 1973 (E. M. Benedict), 2 males, 2 females (EMB), 6 mi S of Crawfordsville (365 m), 15 September 1973 (E. M. Benedict), 1 nymph (EMB): *Utah*; Cedar Canyon, 8 June 1934 (W. Ivie), 1 male (JCC), Hughes Canyon, 20 May 1934 (W. Ivie), 1 nymph (JCC), Cache Co., Logan Canyon, 1 May 1959 (G. F. Knowlton), 1 male 1 nymph (WBM), 3 November 1963 (G. F. Knowlton), 1 male, 1 female, 1 nymph (WBM), 15 April 1970 (G. F. Knowlton), 1 female (WBM), 23 April 1970 (G. F. Knowlton), 1 male (WBM), 23 June 1970 (G. F. Knowlton), 2 males, 2 nymphs (WBM), 25 June 1970 (G. F. Knowlton), 1 male (WBM), 29 June 1970 (G. F. Knowlton), 1 male (WBM), Fork Canyon, 25 April 1959 (G. F. Knowlton), 2 nymphs (JCC); Rich Co., 7 mi W of Woodruff, 22 July 1970 (G. F. Knowlton and Whitworth), 1 male (WBM); Salt Lake Co., Salt Lake City, no date (R. V. Chamberlin), 1 female (JCC), Mill Creek Canyon, 21 August 1941 (J. C. Chamberlin), 2 males, 2 females, 1 nymph (JCC); San Pete Co., Maple Canyon, 20 August 1924 (R. V. Chamberlin), 1 male, 1 female (JCC), 18 June 1970 (G. F. Knowlton and Judd), 1 male (WBM); Sevier Co., Clear Creek, Raft Mts., 4 September 1932 (R. V. Chamberlin and W. Ivie), 1 female, 1 nymph (JCC); Utah Co., Timpanogos Park, American Forks Canyon, 19 August 1941 (J. C. Chamberlin and W. Ivie), 2 males, 2 females (JCC): *Washington*; Adams Co., Othello, 4 February 1963 (R. Harwood), 1 male (WBM).

Pseudogarypus hesperus Chamberlin

Figs. 5, 12-13, 24-29

Pseudogarypus hesperus Chamberlin 1931:232; Beier 1932:239; Jacot 1938:301; Hoff 1958:18; *nec* Manley 1969:7, 12 (misidentification).

Table 9.—Measurements (in mm) of *Pseudogarypus hesperus* Chamberlin nymphs (abbreviations: B—breadth, D—depth, L—length; ?—indeterminable).

	Tritonymph (n=1)	Deutonymphs (n=4)	Protonymph (n=1)
Body L	1.72	1.30-1.64	1.65
Abdominal B	1.16	0.81-1.06	0.80
Carapace L	0.47	0.39-0.41	0.30±
Ocular B	0.32	0.28-0.29	0.28
Posterior B	0.44±	0.40±-0.47±	0.37±
Ant. eye diam.	0.056	0.043-0.056	0.028
Post. eye diam.	0.062	0.043-0.046	0.037
Chelicera L/B	?	?	0.13±/0.09±
Pedipalps			
Trochanter L/B	0.26/0.17	0.22-0.23/0.13-0.15	0.18/0.12
Femur L/B	0.73/0.18	0.54-0.59/0.13-0.14	0.43/0.11
Tibia L/B	0.41/0.17	0.32-0.34/0.14-0.18	0.24±/0.11±
Chela (inc. pedicel) L	0.98	0.74-0.82	0.64±
Chela B	0.25	0.18	?
Chela D	0.20	0.15-0.16	0.13
Hand L	0.37	0.27-0.31	0.22
Movable finger L	0.56	0.44-0.49	0.38
Leg I			
Basifemur L/D	0.25/0.09	0.18-0.20/0.07-0.08	?/0.06
Teloferum L/D	0.33/0.12	0.17-0.21/0.07-0.08	0.14/0.06
Tibia L/D	0.21/0.07	0.15-0.17/0.16	0.12/0.05
Tarsus L/D	0.36/0.07	0.25-0.31/0.05-0.06	0.24/0.04
Leg IV			
Basifemur L/D	0.23/0.09	0.13±/0.07±	0.14±/0.06±
Teloferum L/D	0.33/0.12	0.24-0.29/0.09-0.10	0.20/0.07
Tibia L/D	0.39/0.09	0.26-0.30/0.06-0.08	0.19/0.06
Tarsus L/D	0.47/0.07	0.36-0.40/0.05-0.06	0.29/0.05

The only valid prior record of *Pseudogarypus hesperus* is the type collection from Washington reported by Chamberlin (1931) in his extremely brief diagnosis. Although Fenstermacher (1959) in his master's thesis and Manley (1969) identified Michigan pseudogarypid specimens as *P. hesperus*, Nelson (1975:283) could find no "reliable criteria to establish the Michigan specimens as a new or existing species." Our examination of types of *P. hesperus* and more than 50 specimens from a number of localities in Oregon reveals that the Michigan specimens (Fenstermacher 1959; Manley 1969; Nelson 1975) are not the same and should be assigned, instead, to the eastern *P. banksi*, as discussed under that species. The two species can be separated by the characters in the key. Since *P. hesperus* has been known only from two females, it seems most useful to give detailed descriptions of all stages so that the range of intraspecific variation may become known.

Diagnosis.—Body length of male 2.32-2.66 mm, of female 2.40-2.85 mm; palpal femur length of male 0.85-0.97 mm, of female 0.93-1.03 mm; epigeal species; chela with retrorse triangular, very closely spaced distal teeth which appear contiguous.

Description.—Measurements in Tables 8 and 9.

ADULTS. Of typical generic facies (Chamberlin 1931, fig. 63) except as noted. Carapace (Figs. 12, 13, 24) only slightly longer than posterior breadth; notch between anterolateral and median protuberance relatively shallow (Figs. 5, 24). Coxal area illustrated by Chamberlin (1931 figs. 20, 21); each coxa I (Fig. 25) bears a cluster of 4-7 scattered pseudospines (average about 5 for each sex). Abdomen broadly obovate and

Table 10.—Measurements (in mm) of type specimens of *Pseudogarypus spelaeus*, new species (abbreviations: B-breadth, D-depth, L-length, ?-indeterminable).

	♂ Holotype	♂ Paratype	♀ Allotype
Body L	3.20	?	3.37
Abdominal B	1.77	?	2.02
Carapace L	0.77	?	0.77
Ocular B	0.39	0.41	0.43
Posterior B	0.56	?	0.60
Ant. eye diam.	0.068	0.078	0.078
Post. eye diam.	0.088	0.088	0.088
Chelicera L/B	?	?	0.34/0.17
Pedipalps			
Trochanter L/B	0.43/0.28	0.44/0.28	0.45/0.28
Femur L/B	1.68/0.23	1.64/0.25	1.73/0.25
Tibia L/B	0.85/0.28	0.84/0.25	0.90/0.25
Chela (inc. pedicel) L	1.80	1.87	1.98
Chela B	0.33	0.35	0.37
Chela D	0.31	0.32	0.34
Hand L	0.67	0.69	0.71
Movable finger L	1.12	1.13	1.21
Leg I			
Basifemur L/D	0.54/0.13	?/0.13	0.60/0.13
Telofemur L/D	0.48/0.14	0.49/0.13	0.56/0.14
Tibia L/D	0.41/0.10	0.41/0.10	0.45/0.10
Tarsus L/D	0.66/0.06	0.72/0.06	0.75/0.06
Leg IV			
Basifemur L/D	0.41/0.14	0.44/0.14	0.43/0.14
Telofemur L/D	0.61/0.15	0.65/0.15	0.66/0.16
Tibia L/D	0.77/0.09	0.79/0.09	0.86/0.10
Tarsus L/D	0.94/0.07	0.96/0.07	0.98/0.07

slightly longer than broad. Appendages typical of epigean species, palp illustrated in Fig. 26 (morphometric ratios Table 1); chelal chaetotaxy and dentition illustrated in Figs. 27-28 (Chamberlin 1931 fig. 38), fixed finger with a graded series of markedly retrorse triangular marginal teeth (male 25-35, female 32-36), distally contiguous and elongate, gradually becoming lower, broader and more widely spaced basally; teeth of movable finger similar in general shape but lower, broader and slightly more separated distally, basally very widely spaced, as much as a tooth's width apart (male 25-30, female 26-30 teeth).

TRITONYMPH. Based only on EB-1432.01001. Similar to adult except as noted. Slightly paler and smaller; derm only slightly less sclerotized. Coxal chaetotaxy 2-3-9-4:0-1-3-PS:0-2-4:0-1-6:0-1-6, each coxa I with 5-6 pseudospines. Chaetotaxy of chela (Fig. 29c) typical of species and nymphal stage. Teeth of both fingers similar to adult in shape but very slightly spaced distally, fixed finger with 28 marginal teeth, movable finger with 23 teeth.

DEUTONYMPH. Similar to adult except as noted. Paler and smaller; derm definitely reticulate to reticulate-spinose but less sclerotized. Coxal chaetotaxy 2-2-3-2:0-1-2-PS:0-1-2:0-1-2:0-1-3, each coxa I with 3 pseudospines. Chaetotaxy of chela (Fig. 29b) typical of species and nymphal stage. Teeth of both fingers similar in shape to adult but slightly spaced, fixed finger with 21-26 marginal teeth, movable finger with 19-22 marginal teeth.

PROTONYMPH. Similar to adult except as noted. Much paler and smaller; derm definitely reticulate to reticulate-spinose but weakly sclerotized. Coxal chaetotaxy 1-1-1-2:0-0-1-PS:0-0-1:0-0-1:0-0-1, each coxa I with 2 pseudospines. Chaetotaxy of chela (Fig. 29a) typical of species and nymphal stage. Teeth of both fingers similar in shape to adult but more widely spaced, fixed finger with 19 spaced marginal teeth, movable finger with 15 well-spaced teeth.

Remarks.—One specimen, which exhibits typical male genitalia, has only three tactile setae on the chelal movable finger. Although most palpal dimensions of this specimen fall within the range of *P. hesperus* males, its body is less well-sclerotized and smaller. In fact, the specimen appears immature when compared to the other male from the same collection. Therefore, it seems inadvisable to include the measurements of this "immature male" in Table 8. Measurements not conforming are body length 2.14 mm; abdominal breadth 1.34 mm; chelal breadth 0.24 mm.

Distribution. The known range of *Pseudogarypus hesperus* extends south from Pierce County, Washington, nearly to the California border and eastward to Umatilla County, Oregon.

Habitat.—This species has been collected most frequently from very flakey and well rotted bark still attached to very large and old living conifers. We attempted to recover it from near the type locality at Puyallup, Washington, but the area has few remaining old-growth trees. Despite more than 30 bark samples from stumps, 5 to 8 feet in diameter, and from older "seed" trees, no new Washington specimens were recovered by Berlese extraction. All but two Oregon specimens came from bark of Douglas and Pacific silver firs, western and mountain hemlock, Englemann spruce and western red cedar. One specimen was recovered from beneath a rock and another captured alive in a spider web inside an outhouse in a forest camp. No specimens have been recorded from coniferous litter.

Specimens examined.—UNITED STATES: *Washington*; Pierce Co., Puyallup, 8 August 1928 (W. W. Baker), 2 females (holotype, paratype JCC); *Oregon*; Clackamas Co., 15 mi S, 6 mi W of Government Camp (1070 m), 26 May 1972 (E. M. Benedict), 1 male, 3 nymphs (EMB), 15 mi S, 1 mi W of

Government Camp (1005 m), 26 May 1972 (E. M. Benedict), 6 males, 6 females, 3 nymphs (EMB), 4 mi N, 6 mi E of Zig Zag (1035 m), 2 September 1972 (E. M. Benedict), 1 nymph (EMB); Jackson Co., Summit of Mt. Ashland (2285 m), 16 September 1972 (E. M. Benedict), 2 males, 2 females (EMB); Jefferson Co., Santiam Pass, 9 mi W, 3 mi S of Camp Sherman (1370 m), 3 September 1941 (J. C. Chamberlin), 1 male (JCC); Lane Co., 9 mi S, 21 mi E of Oakridge (1495 m), 24 June 1972 (E. M. Benedict), 3 males, 1 female, 3 nymphs (EMB), 20 mi S, 14 mi E of Oakridge (1525 m), 16 August 1973 (E. M. Benedict), 3 males, 2 females, 6 nymphs (EMB), 16 mi N, 8 mi E of Oakridge (1525 m), 30 August 1973 (E. M. Benedict), 1 nymph (EMB); Lincoln Co., Saddleback Mt., 1 mi S, 10 mi E of Lincoln City, 15 May 1937 (J. A. MacNab), 1 female (JCC); Linn Co., Santiam Pass, 2 mi N, 31 mi E of Sweet Home (1465 m), 24 June 1972 (E. M. Benedict), 1 male, 1 female (EMB), 1 mi N, 28 mi E of Sweet Home (1190 m), 24 June 1972 (E. M. Benedict), 1 female, 1 nymph (EMB), 13 mi N, 23 mi E of Sweet Home (580 m), 29 April 1972 (E. M. Benedict), 1 nymph (EMB), 12 mi N, 28 mi E of Sweet Home (1220 m), 17 September 1973 (E. M. Benedict), 2 females, 2 nymphs (EMB); Polk Co., 8 mi E of Valsey (670 m), 11 June 1973 (E. M. Benedict), 3 males, 1 female, 3 nymphs (EMB); Umatilla Co., Woodward Camp, 33 mi N of La Grande (1540 m), 7 August 1972 (J. J. Kirk), 1 female (EMB).

Pseudogarypus spelaeus new species

Figures 7, 30-32

Type records.—United States: California; Shasta Co., about 20 mi NE of Redding, Samwell Cave (442 m), 11 June 1959 (R. E. Graham), holotype male, DM-407.01001, (AMNH), 30 June 1959 (R. E. Graham), allotype female, DM-406.01001, (AMNH), 22 June 1959 (R. E. Graham), paratype male, DM-405.01001 (DRM).

Etymology.—The specific name, derived from the Greek word, *spelaeion*, for “cave” is given in recognition of the first species of the family Pseudogarypidae known to exhibit cavernicolous tendencies.

Distribution.—The species is known only from Samwell Cave, California, a “Pleistocene bone cave,” with a mapped length of 275 m and a vertical depth of 250 m in Permian McCloud limestone (Halliday 1962).

Diagnosis.—Body length of male 3.20 mm, of female 3.36 mm; palpal femur of male 1.64-1.65 mm, of female 1.73 mm; attenuate, cavernicolous species; chela with widely spaced teeth.

Description.—Measurements in Table 10.

ADULTS. Carapace (Fig. 32) about 1.4 times longer than posterior breadth; notch between anterolateral and median protuberances relatively deep; corneas of eyes slightly flatter than epigeal species. Each coxa I (Fig. 31) bears a scattered cluster of 4-9 pseudospines (average about 7.5 for male). Abdomen (Fig. 32) obovate, about 1.3 times as long as broad. Appendages attenuate (morphometric ratios Table 2); chelal chaetotaxy and dentition illustrated in Fig. 30; fixed finger with graded series of widely spaced elongate teeth (males with 44-47; female 41), moderately triangular retrorse distally, gradually becoming lower, broader, less retrorse and rounder basally; movable finger with broad retrorse triangular teeth distally, broader and higher medially, and lower, rounder and less retrorse basally (male with 36-40; female 36).

NYMPHAL STAGES. Not represented in collection.

Remarks.—*Pseudogarypus spelaeus* exhibits a degree of cavernicolous modification in the somewhat reduced eyes, giantism, and attenuation of appendages, especially of the palpal femur.

ACKNOWLEDGEMENTS

The authors acknowledge with gratitude the use of research facilities at the Malheur Field Station, near Burns, Oregon. We also appreciate the donation of scanning electron micrographs by Clara M. Fairfield of the Oregon Museum of Science and Industry and by MEI Charlton Laboratories, both of Portland, Oregon; the preparation of drawings by Susan Lindstedt and photographs by Patricia Barnhart; and the loan of specimens by Herbert Levi of the Museum of Comparative Zoology (MCZ). We are especially grateful to William B. Muchmore (WBM) for the loan of numerous specimens. The holotype and allotype of the new species are deposited in American Museum of Natural History (AMNH). All other specimens remain in the combined Benedict-Chamberlin-Malcolm Collection (EMB, JCC, and DRM).

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REDESCRIPTION OF *CERATOLASMA TRICANTHA* GOODNIGHT AND GOODNIGHT, WITH NOTES ON THE FAMILY ISCHYROPSALIDAE (OPILIONES, PALPATOIRES)

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ABSTRACT

Ceratolasma tricantha Goodnight and Goodnight, 1942, is redescribed in both sexes; descriptions and figures of most features of external morphology and some details of anatomy are given. Known distribution of the species is mapped. The arguments for the systematic rearrangement (*Ceratolasma* placed near *Ischyropsalis* in Ischyropsalidae) are expanded; some features of the latter genus are examined in comparison. The genus *Ruaxphilos* Goodnight and Goodnight, 1945, is considered a synonym of *Ortholasma* Banks. Questions of delimitation of and generic groupings in the family Ischyropsalidae are discussed.

INTRODUCTION

The genus *Ceratolasma*, with its only species *C. tricantha*, was established in 1942 by C. J. and M. L. Goodnight as a member of the Trogulidae. No further material had been published until 1969, when I described a stridulating organ in the species, and transferred the genus to Ischyropsalidae. Martens (1969a) placed *Ceratolasma* close to *Ischyropsalis* and added descriptions of morphological details. This new placement has been followed by Ljovushkin (1971), Shear (1975), and Dumitrescu (1975). Since the original description was based on only one female, and subsequent publications only discussed certain aspects of the morphology, a detailed redescription seems justified, including a discussion of problems of systematic placement.

Material examined is deposited in the American Museum of Natural History (AMNH) and the California Academy of Sciences (CAS); a few specimens are in the Naturhistorisches Museum Wien (NHMW).

Family ISCHYROPSALIDAE Simon

At the time of its foundation by E. Simon in 1879, the family contained the genera *Ischyropsalis* C. L. Koch (previously in Nemastomatidae Simon 1872), *Taracus* Simon 1879, and *Sabacon* Simon 1879. It attained its classical definition in the work of Hansen and Sørensen (1904), whose formulations were largely accepted by Roewer (1914, 1923).

The latter included the genera *Ischyropsalis*, *Taracus*, *Tomicomerus* and *Sabacon*. Four genera have been added in later years: *Ruaxphilos* Goodnight and Goodnight, 1945, *Nipponopsalis* Martens and Suzuki, 1966 (for east Asian species formerly in *Ischyropsalis*), *Ceratolasma* Goodnight and Goodnight (Gruber, 1969), and *Hesperonemastoma* Gruber, 1970 (for North American species formerly in *Nemastoma*).

The morphological diversity of the family, noted by Hansen and Sørensen, is much greater than that of the rather homogenous families of the Troguloidea (s.str.). Some authors (Martens 1969a) have commented on the heterogeneity of the family, and Dresco (1970) established a separate family for the genus *Sabacon* (in 1952 he had surmised a possible relationship between *Sabacon* and *Nemastoma*). In Ischyropsalidae, he retained the genera *Ischyropsalis*, *Taracus*, *Nipponopsalis*, and (with reservations) *Tomicomerus*. The reasons given for this rearrangement were, however, not convincing, and it has not found general acceptance (compare critical remarks in Martens 1972, Dumitrescu 1975, and especially in Shear 1975). Recently, Martens (1976) has revalidated the family Sabaconidae, without giving an explicit diagnosis, though he mentions differences in ovipositor form which do not seem significant to me.

On the other hand, the exclusion of certain nonconforming elements has lessened the heterogeneity of the Ischyropsalidae: *Nipponopsalis* now is in Troguloidea (family Nipponopsalididae Martens 1976), mainly on the grounds of genital morphology and sternal configuration. It may be noted that Suzuki (1973, Fig. 152) figured the typically troguloid ovipositor of *Nipponopsalis abei longipes*. Miyosi (1942) described "drumstick-like hairs" on the palpi of juvenile *N. abei*, which may be clavate hairs of the type known hitherto only in Nemastomatidae and juvenile *Dicranolasma*. This would corroborate the new placement, but studies of the fine structure of the hairs in question are still lacking.

The genus *Ruaxphilos* should be removed from the family; its only species, *R. petrunkevitchou* Goodnight and Goodnight), is a probable synonym of *Ortholasma* (= *Trilasma*) *bolivari* (Goodnight and Goodnight). Examination of the holotype (in the Field Museum of Natural History, Chicago), showed that it is a very young nymph which certainly does not belong to Ischyropsalidae, as indicated by the presence of clavate hairs on the palpi. This placement has also been suggested by Shear (1975), but he did not examine the holotype.

In the family, as understood here, remain the genera *Ceratolasma*, *Hesperonemastoma*, *Ischyropsalis*, *Sabacon*, and *Tomicomerus*. Doubts remain on the systematic positions of the following genera. *Sabacon* may after all require a separate family, or subfamily, but the relationship of this genus to *Tomicomerus* must be clarified. *Tomicomerus* seems to have characteristics of both "sabaconids" and of Ischyropsalidae, but inadequate material exists to resolve the question (Shear 1975, Dresco 1970). *Hesperonemastoma* is quite aberrant in, for example, scutum type and midgut anatomy (Dumitrescu 1975, Shear 1975); it may belong in yet another separate family with *Crosbycus* and an undescribed genus from Washington state (Shear, in litt.).

Apart from the possibly intermediate position of *Tomicomerus*, a family Sabaconidae seems to lack justification because of the absence of "distinct gaps" in several character series which serve as unifying traits of the family Ischyropsalidae, in its wider sense: midgut anatomy (Dumitrescu 1975), which suggests other groupings of the genera, the concededly trivial paired (*Sabacon*, *Tomicomerus*, *Ceratolasma*) or multiple (*Ischyropsalis*) armature of the second thoracic tergite, and the rudimentary palpal claw. The latter is mostly characterized as "lacking" in *Sabacon*, but according to my own limited experience this is not generally valid. In juvenile *Sabacon* I found peg-shaped

structures on the tips of the palpal tarsi which resemble the claw rudiments of other genera (compare Figs. 29, 21, 28). The "enigmatic sensillum" of Fig. 4 in Thaler (1976) seems to be the same thing. It is easy to overlook the tiny peg in the dense hair cover of the palpi.

A more formal argument concerns the status of the remnant family Ischyropsalidae, created as a coordinate group if one accepts Sabaconidae. The latter, as a monobasic family based on a well-defined, natural genus, as evidenced by several autapomorphies of *Sabacon*, would logically be a monophyletic group; the diminished Ischyropsalidae, however, remain a heterogenous, poorly defined paraphyletic group. This situation may lead to further splitting, resulting finally in a preponderance of monobasic families, an undesirable state of affairs against which Hansen and Sørensen (1904:77) uttered warning words.

It seems preferable at the present time to retain the family Ischyropsalidae in its classical Hansen and Sørensen form, with modifications of diagnosis and content as necessitated by more recent discoveries (see Gruber 1970:132). Perhaps other conclusions will be possible when all genera have been revised and a renewed comparative evaluation of characters is available. However, questions of family delimitation in this group now seem less urgent since Martens (1976) has clarified its position in the whole of Palpatores, as a well defined superfamily Ischyropsaloidea clearly separated from the Troguloidea. Female genital morphology may be a key character of the group, the very short, unsegmented ovipositor with its undivided furca and mostly hairless corpus probably being an apomorphic feature of the superfamily.

A family diagnosis can only be preliminary, since the related, but aberrant genus *Crosbycus*, of uncertain position (Martens 1976), has not yet been fully described, but may run as follows: Ischyropsalidae are Ischyropsaloidea with normally developed leg coxae (without large basal endites or separate sclerite plates), pedipalpi with a peg-shaped claw-rudiment (*Sabacon*?). Formal recognition of subfamilies or other groups in the family still seems premature. Below I suggest a generic grouping which appears more natural and promising than the separation of just one specialized genus in its own family.

Genus *Ceratolasma* Goodnight and Goodnight

Ceratolasma Goodnight and Goodnight 1942:3, Roewer 1950:54, Gruber 1969:249, Martens 1969a:184, Gruber 1970:134, Ljovushkin 1971:130, Martens 1972:312, Dumitrescu 1975:151, Shear 1975:8, 10.

Type species.—*Ceratolasma tricantha* Goodnight and Goodnight, 1942 (by monotypy).

Diagnosis.—The genus is unique among the known Ischyropsalidae because of the frontal processes of eye tubercle and carapace, which hide the short chelicerae and palpi in trogulid-like fashion.

Description.—Carapace includes thoracic tergites, the prethoracal part with caudo-lateral extensions to the sides of the laterally free second thoracic tergite. Frontal carapace margin with narrow median extension between cheliceral bases to base of epistome. Narrow lateral pieces ("pièces épimeriennes" of Simon 1879) of carapace continuous only with anterior carapace margin; ozopores not easily visible. Eye tubercle near anterior carapace margin, with median process, two similar processes on carapace to the sides of the eye tubercle. Opisthosoma with scutum parvum. Free tergites partially visible from

above. Corona analis with triangular lateral sclerites (=tergite 9) and anal sternite. Genital operculum demarcated posteriorly by furrow. Spiracles kidney-shaped, latticed, not visible in strictly ventral view. Prosomal venter with free sternum; labium large, trapezoidal, without setae. Leg coxae more or less immovable. Second to fourth coxae with small endites. Endite of first coxa with one oval movable sclerite. Labrum with horn-shaped process. Chelicerae and palpi short. Chela with narrow, diaphanous teeth and one dark, robust tooth near apices of fingers. Males with glandular areas on basal articles of chelicerae. Palpi stout, articles not inflated. Tibia and tarsus of palpus of about the same length, longer than patella, femur longer than patella. Patella, tibia and tarsus with microtrichia; no glandular setae. Peg-shaped rudiment of palpal claw short. The only known species has stridulating organs formed by chelicerae and palpal femora. Leg metatarsi with two distal spurs. No differentiated calcaneus, but marked difference in microsculpture and vestiture between basal and distal portions of metatarsi, with strongly inclined transition plane. Number of tarsal articles moderate.

Penis sheath with two sclerotized bands. Penis of simple shape, stout, tapering distally, tendon of muscle short. Glans conical, symmetrical, with numerous short, uniform setae. Stylus well differentiated, not reflexed when at rest. Ovipositor short, broad, corpus without hairs, distal part (furca) without visible dorsoventral differentiation, sparse setation around furcal base, group of shorter setae near apex of each distal lobe. Opening cleft symmetrical, bordered with densely spaced rows of small spines. Receptacula seminis short, rounded, saclike.

Relationships.—The original placement in Troglidae was founded on a superficial resemblance to the ortholasmatine species of western North America, which likewise do not belong to this family (Martens 1969a, 1976). Despite the very different appearance, *Ceratolasma* is the closest relative of the European genus *Ischyropsalis*. It agrees with the latter in the following features: carapace with median anterior extension and well differentiated lateral pieces; free sternum and large labium; complex midgut (Dumitrescu 1975); ovipositor with spines bordering the apical opening and with setae of furca in basal and apical groups; soft lobes of palp endites with brushlike trichome groups (compare Fig. 7 in Avram 1975); palpi without plumose glandular setae and with pubescence of microtrichia on distal articles. Differences from *Ischyropsalis* comprise: eye tubercle near anterior margin of carapace, ozopores and spiracles not freely visible, ovipositor symmetrical.

If one disregards specializations connected with the troglid-like body form and the stridulating organs, *Ceratolasma* shows a preponderance of more primitive character states: simpler penis shape, ovipositor without marked dorsoventrality and with saclike, not elongated, receptacula; sclerites of body more complete (freely visible ozopores and spiracles in most other ischyropsalids may be connected with sclerite reduction; Gruber 1970); first coxal endite with only one sclerite; chelicerae and palpi not elongated, chela with normal dentition.

Some of these traits merit a short discussion:

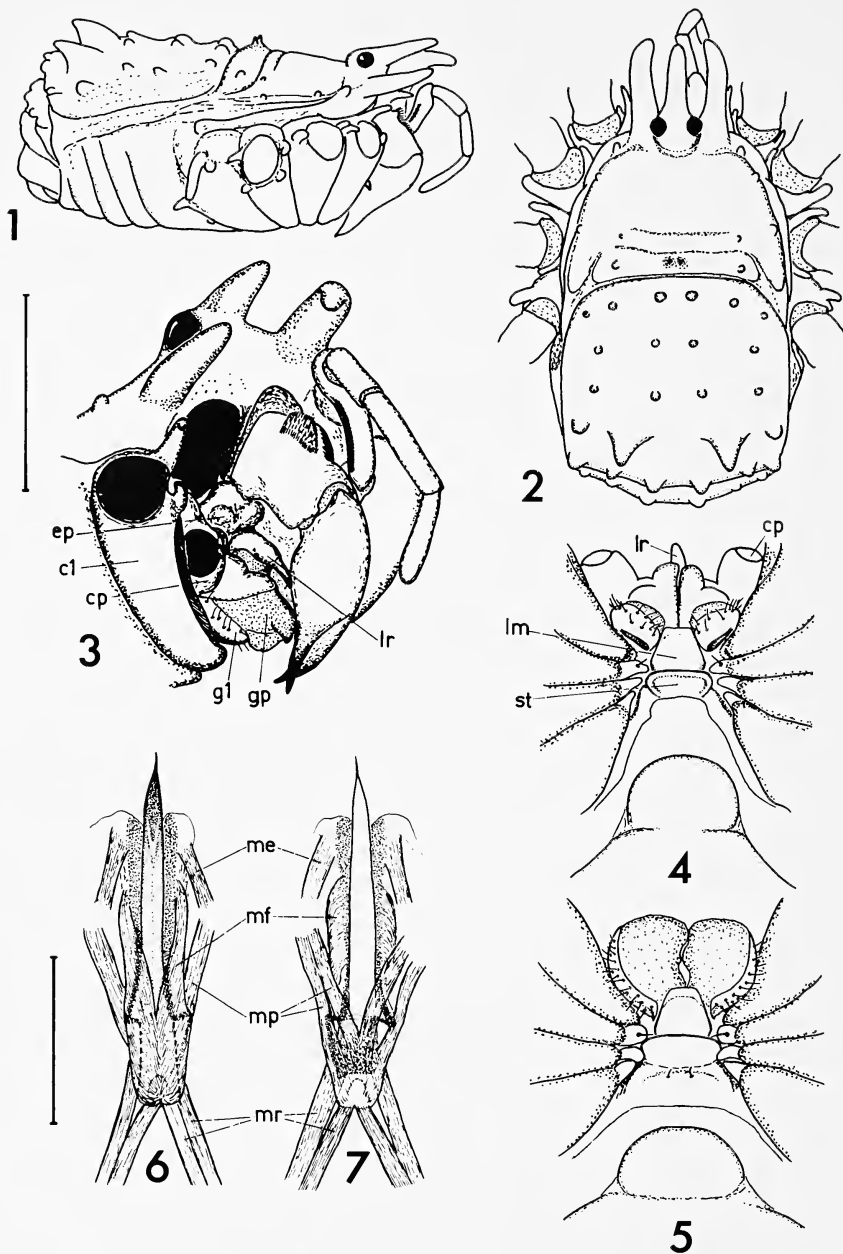
1. Ovipositor: Most ischyropsalid ovipositors are short and only sparsely set with setae, in the apical portion, resembling the "stumpy type" described in *Sabacon* by Suzuki (1974). The more troglid-like "elongate" and "short" types (with setae on the corpus) are derived in *Sabacon*, according to this author. Together with the prevalence of "stumpy type-like" ovipositors in the other genera this speaks for the primitive nature of this type in the whole family. In *Ischyropsalis* species there is a distinct trend to dorsoventrality in the distribution of setae and the position of the secondary genital opening.

Specimens of *I. kollari* and *I. hellwigi* were examined; in the first species the opening is symmetrical, and there are only a few setae on the ventral surface; in *I. hellwigi* the opening is largely dislocated to the dorsal side, and setae are lacking on the ventral surface.

2. Coxal endite of first leg: the two movable sclerites of *Ischyropsalis* (Martens 1969a) probably correspond together to the one sclerite in *Ceratolasma*, as evidenced by a comparable concavity on the basal sclerite in *Ischyropsalis* and near the base of the sclerite in *Ceratolasma*. Secondary subdivision in the former genus seems more plausible than the reverse.

3. Chelicerae: Short or moderately long chelicerae, as in *Ceratolasma* (Fig. 15), *Hesperonemastoma*, *Sabacon* or *Tomicomerus*, have fingers armed with rows of closely spaced, narrow, diaphanous teeth (as typical for "Dyspnoi"), with ordinarily one subapical broad, blunt, darkened tooth on each finger. Elongated chelicerae (*Ischyropsalis* and *Taracus*) have more of the dark, coarse dentition; *Taracus*, and especially *Ischyropsalis*, have rows of coarse teeth near the finger bases (Müller 1924, Roewer 1923, Ljovushkin 1971). It seems that elongation of the chelicerae and their fingers has led to intercalation of additional stretches of cutting edge in different parts of the chela in the diverse genera; another argument for the independent derivation of the *Ischyropsalis*-like forms. The widely held opinion that long chelicerae are "simply adaptations to snail eating (Shear 1975)" is not substantiated by facts, even Shear cites evidence to the contrary for *Taracus*. Martens (1975) states that, in *Ischyropsalis*, only *I. hellwigi* is a specialized snail eater, the other species preferring arthropods as prey. The presence of presumably glandular hairs on the palpi of *Taracus* and *Nipponopsalis*, at least in juveniles may point to habits of the latter sort in these genera. If my guess is correct, these palpi act as sticky traps which are primarily aimed at arthropod prey.

Ceratolasma differs sharply from the other American genera of the family, by the vestiture of the palpi and the sternolabial configuration alone. As indicated above, these two character complexes allow us to discern two groups of genera: The first (*Ischyropsalis* and *Ceratolasma*) shows a prominent sternum, large labium, palpi without plumose setae, but with numerous microtrichia, and also a complex midgut anatomy. The second group (*Taracus*, *Hesperonemastoma*, *Tomicomerus*, *Sabacon*) shows less developed sterna, small labia, palpi with extensive development of plumose setae and reduction of the microtrichial cover; the midgut anatomy, though generally simpler, is less uniform and may point to a heterogenous nature for the second group. Closer analysis will be needed for a definitive taxonomic evaluation of these groups. Contradictory statements concerning the sternal region in *Taracus* in Martens and Suzuki (1966) and in Martens (1969), and the erroneous description based on insufficient material given by Gruber (1970) for *Hesperonemastoma* are examples of the lack of precise knowledge even in the recent literature. Concerning the palpal vestiture, neither of the states described above seems to be primitive: well developed microtrichia seem a primitive trait, as judged by comparison with other families (Sironidae, Phalangiidae), and by comparison with the serially homologous legs. Reduction of microtrichia on the palpi seems to be correlated with the specialized functions of these appendages. In the Laniatores, the same situation occurs. On the other hand, glandular setae of the plumose type seem to be primitive for the Palpatores, as judged from their presence in all three non-troguloid superfamilies. Their precise location on the palpi, and presumably their function, varies between the groups (Ischyropsaloidea versus Caddoidea-Phalangioida). Their absence in the *Ischyropsalis*-*Ceratolasma* group therefore may be secondary, while their excessive development in the other group, most marked in *Sabacon*, is clearly a specialization.



Figs. 1-7.—*Ceratolasma tricantha*, external and genital morphology: 1, male, lateral view of body; 2, male, dorsal view of body; 3, male, frontal body wall and camerostome in oblique view (right chelicera, right palpus and legs removed); 4, male, sternal region with proximal parts of coxae, ventral view (genital operculum removed, figured as inset below); 5, female, as in 4; 6, male, penis with penis sheath and its muscles, ventral view (penis sheath opened longitudinally, its sclerotized bands bent near base); 7, same, dorsal view (penis in outline). cp, palp coxa; cl, first leg coxa; ep, epistome; gp, palp gnathocoxa; gl, gnathocoxa of first leg; lm, labium; lr, labrum; st, sternum; me, closer of genital opercule; mf, muscle running ventromedian to dorsodistad on penis sheath; mp, protractor muscles; mr, retractor muscles of penis. Upper scale: 2 mm for Figs. 1, 2. 1 mm for Figs. 3, 4, 5. Lower scale: 1 mm for Figs. 6, 7.

Distribution.—The genus, according to our present knowledge, is confined to the western Nearctic. The only known species has a rather restricted range in the humid coastal regions of Oregon and northern California. Biogeographical links to the eastern Nearctic or the eastern Palearctic, as known in several other phalangid groups, are not evident; the closest living relative, *Ischyropsalis*, occurs in the western Palearctic. This type of holarctic disjunction is comparatively rare, at least among animals, the salamander *Hydromantes* being cited most often (Udvardy 1969, Wake 1966). Other examples, mainly from Coleoptera, are given by Halffter 1964, Jeannel 1942, Linsley 1958 and Van Dyke 1926. In our case it is certainly old, predating the Tertiary, in view of the strong morphological differentiation (Wake 1966, surmises early Eocene for *Hydromantes*).

Ceratolasma tricantha Goodnight and Goodnight
Figs. 1-28, Map 1

Ceratolasma tricantha Goodnight and Goodnight 1942:3, fig. 3, Roewer 1950:54, Gruber 1969:249, figs. 1, 2, Martens 1969: 186, figs. 30, 31, Ljovushkin 1971:131, Dumitrescu 1975:153, 155, fig. 21.

Types.—Holotype female, from Clear Creek, near Forest Grove, Washington Co., Oregon; deposited in AMNH; not seen.

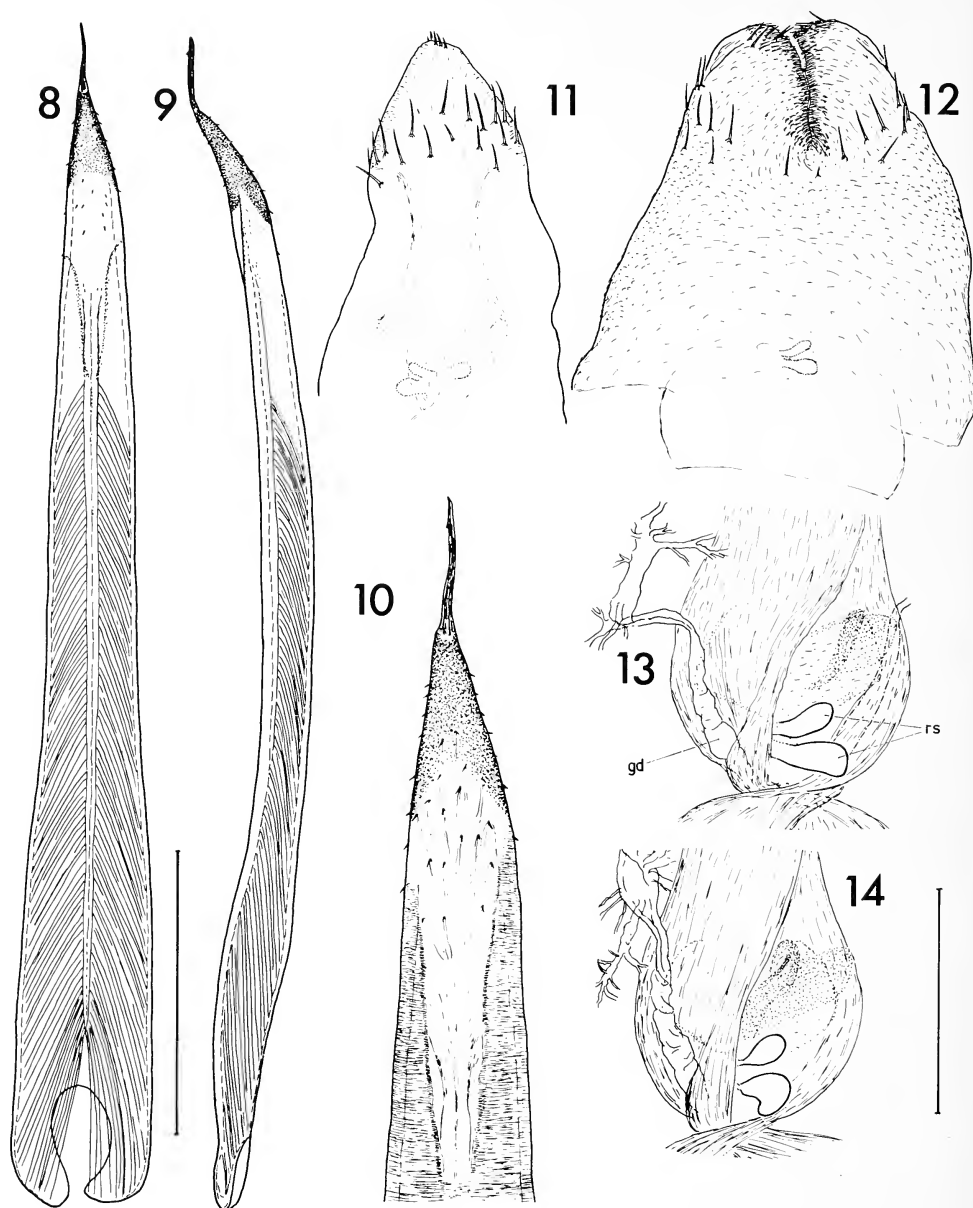
Diagnosis.—Genus monotypic.

Description.—The following redescription is based chiefly on a male from Bogus Creek, Oregon, and a female from Canyonville, Oregon; accidentally these are, respectively, the smallest and largest specimens seen.

Body flattened dorsally (Fig. 1); in dorsal view (Fig. 2) approximately rectangular in outline with parallel sides, posterior margin slightly convex.

Body sclerites stiff-leathery, often with diffuse edges against smooth membranes; their surfaces coarsely granulated or finely denticulated (excepting sternal area, coxal endites, mouthparts, etc.). Microscopically small granules are scattered between visible denticles. Pilosity of body sparse, on dorsal side especially inconspicuous, more distinct on venter; consisting of small, short setae with rounded tips. Body macrosculpture of rounded tubercles or warts of various sizes and forms, with granulated surfaces and white cores or tips, excepting the wholly brown cones on the second thoracic tergite.

Eye tubercle demarcated behind by curved groove, with nearly horizontal, blunt-conical process in front. Carapace processes to the sides of the eye tubercle similar, curved slightly mesiad and directed slightly upwards. These may sometimes be longer than the median process, as in the specimen figured (Figs. 1, 2). Carapace with scattered small tubercles, three larger ones near lateral margins on each side, the foremost before curved end of suture delimiting the lateral pieces. Prethoracic carapace with triangular caudolateral extensions on the sides of the second thoracic tergite, separated from latter by membrane wedges extending from behind (Fig. 2). Thoracic tergite 1 demarcated by shallow transverse groove anteriorly, with a small tubercle on each side, a few tiny ones in transverse row. Second thoracic tergite delimited by deeper transverse groove anteriorly; with broad median swelling bearing two closely spaced, blunt, conical spines with relatively smooth surfaces, lateral parts with a small tubercle on each side. Narrow lateral pieces to the sides of the carapace proper (Figs. 1, 2) delimited by narrow membrane folds extending anteriorly to height of first coxae, where the sutures curve mesiad in direction of the posterior eyemound margin and grow indistinct in the carapace. Anterior



Figs. 8-14.—*Ceratolasma tricantha*, genital morphology: 8, penis, ventral view (muscle and tendon shown); 9, same, lateral view; 10, penis, apical part in ventral view; 11, ovipositor, lateral view (only setae shown of superficial structures; extent of opening cleft and its spine border, situation of vagina and seminal receptacles indicated); 12, same, viewed from flat side (slightly squeezed. Superficial structures and outline of seminal receptacles on one side shown); 13, part of inner structures of ovipositor (vagina, seminal receptacles and branched ducts of glands on one side shown); 14, same, viewed from other side. gd, gland ducts; rs, seminal receptacles. Left scale: 0.5 mm for Figs. 8, 9, 11, 12. Right scale: 0.22 mm for Figs. 10, 13, 14.

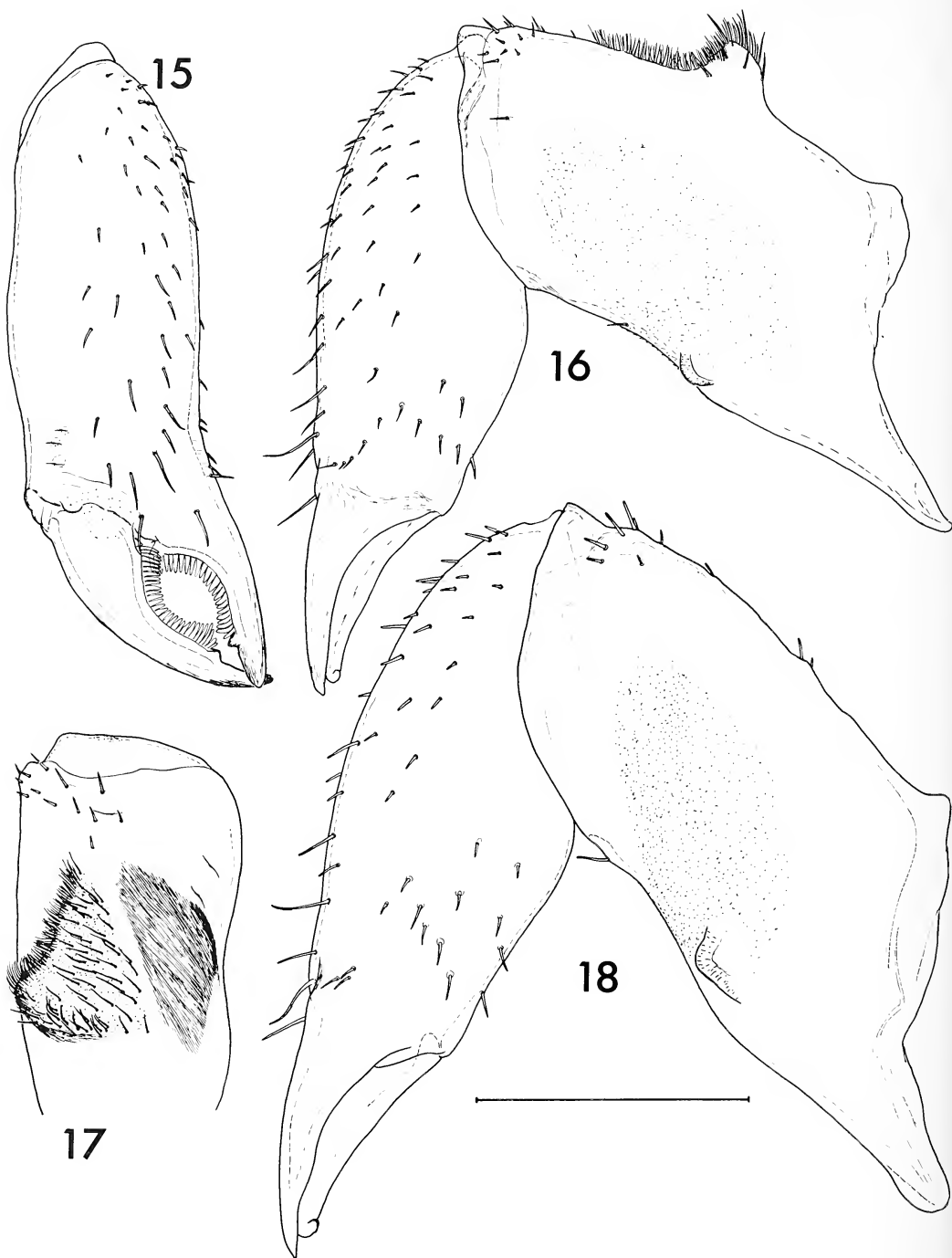
part of lateral pieces slightly convex, white plates above first coxae, continued caudad as narrower strips with dark hypodermal pigment. Ozopores small oval openings in the membranes above first coxae, not visible from above.

The conditions described above apply mainly to males. In females, especially gravid ones, the body is oval, its dorsal side more convex, all membrane folds are strongly distended, forming a broad transverse zone between scute and carapace. A broad wedge of membrane extends anteriorly to the sides of the second thoracic tergite, another one between carapace proper and lateral pieces, separating the posterior part of the carapace widely from the lateral pieces which remain close above the coxae. This tilting of the carapace, which also occurs in *Ischyropsalis*, seems to allow more room for the accommodation of increased body contents; one may see here a functional reason for the differentiation of "pièces épimériennes." The posterior parts of the lateral pieces show membranous divisions from their anterior parts; also the triangular caudolateral carapace flaps are more or less detached.

Opisthosomal scute of approximately square outline (Fig. 2), margins slightly convex. Segmental pairs of tubercles largest on area 4, smaller on posterior margin of area 5. Large tubercles of fourth area broad, conical, slanted caudad, more widely spaced than other pairs. Lateral parts of areas with one, two or three smaller tubercles on each side. Narrow free tergites 6 and 7 with similar, lower sculpture. Tergite 8 curved, with very low tubercles. Tergite 9 represented by two triangular lateral sclerites. Anal operculum rounded-triangular. Anal sternite small, without visible subdivision. Free sternites narrow. Genital operculum delimited by shallow groove on posterior margin; nearly semicircular in male, broader in female (Figs. 4, 5). Spiracles rather large, elongated, kidney-shaped, densely latticed; not visible in strictly ventral view, situated in the posterior wall of the deep cleft between fourth coxa and opisthosoma, near the ventral edge. Anterior edge of spiracular sternite slightly indented below spiracle, the latter hidden by small, slightly convex fold.

Leg coxae rounded, without marginal rows of tubercles; their surfaces coarsely granulated; distal ends with whitish tubercles, at most two on dorsal and ventral sides of each coxa, the dorsal ones elongated into blunt spines, those on prolateral side of the first coxa large and curved, here also on ventral side a lower tubercle (Figs. 1, 2, 3). Second to fourth coxae with small endites, which lack granulation and are darker brown, those of coxae 2 with one seta each (in one female there were two setae on one side; Figs. 4, 5). Between posterior coxae a well developed, transversely oval sternum (Figs. 4, 5), its anterior and lateral edges protruding, its posterior margin less well defined, merging into area of pale cuticle between fourth coxae, in females two setae are found here. Other sexual differences in the shape of the sternum correspond to those of the overlying genital operculum (Figs. 4, 5). Anterior to sternum a large, hairless, trapezoid labium, its basal part connected to the endites of the first coxae, its distal part membranous (this differentiation more clearly marked in the female). Endites of the first coxae with one movable, oval setose sclerite, with an elongated concavity near its base (Figs. 4, 5).

The hood-camerostome complex is the typical trait of opilionids with a troglud-like body. As hood I define here any roofing structure above the mouthparts, formed by processes of eye tubercle and carapace; as camerostome, more or less following Simon (1879), a space containing the anterior appendages when folded back at rest, delimited above the hood, at the sides partly by the latter, partly by the prolateral walls of the first coxae, aided by processes of the latter. In *C. tricantha*, the first coxae are curved distinctly anteriorly, their prolateral (anterior) walls, enlarged by the longer dorsal and shorter



Figs. 15-18.—*Ceratolasma tricantha*, chelicerae: 15, male, right chelicera, second and third articles in frontal view; 16, male, right chelicera, prolateral view; 17, male, right chelicera, basal article in dorsal view (basal portion omitted. Setae of gland area and ridges of stridulation area not individually shown); 18, female, right chelicera, prolateral view. Scale: 0.5 mm.

ventral spined tubercle, form the ventral part of the camerostome side limits (Figs. 1, 3). The dorsolateral and dorsal roofing is formed by the three large processes of eye tubercle and carapace, the latter evidently enlarged tubercles of the type occurring on the body surface. The frontal body wall, limiting the camerostome caudally, is nearly vertical (female) or even inclined backwards (male). It includes, below the hood, a downturned rim of the carapace and a narrow median prolongation between the cheliceral bases, reaching the epistome. It contains the epistome, labrum, and cheliceral and pedipalp insertions. Epistome broad, convex, with two low swellings placed side by side. Labrum delimited from epistome by deep curved groove, its dorsal part with horn-shaped process, its ventral side with soft membranous wedge between the palpal endites (Fig. 3).

Chelicerae (Figs. 3, 15-18) short, total length about half of body length. Cuticle smooth, shining, fine denticulation on ventromesial sides of basal article. Basal article in males with glandular area in middle of dorsal side; this area slightly concave, sparsely set with hairs, more densely so on upturned mesiocaudal margin, which is drawn up into a triangular tip posteriorly (Figs. 3, 16, 17). Opaque glandular tissue extends ventrad to about a third of the height of the article. Laterally from glandular area, a very dark convex area bearing closely spaced striae about parallel to distal margin of the article forms the "file" of the stridulating organ. Females with smooth dorsal contour, lacking glandular area, stridulating area as in males (Fig. 18). Chela short, with typical dentition (Fig. 15).

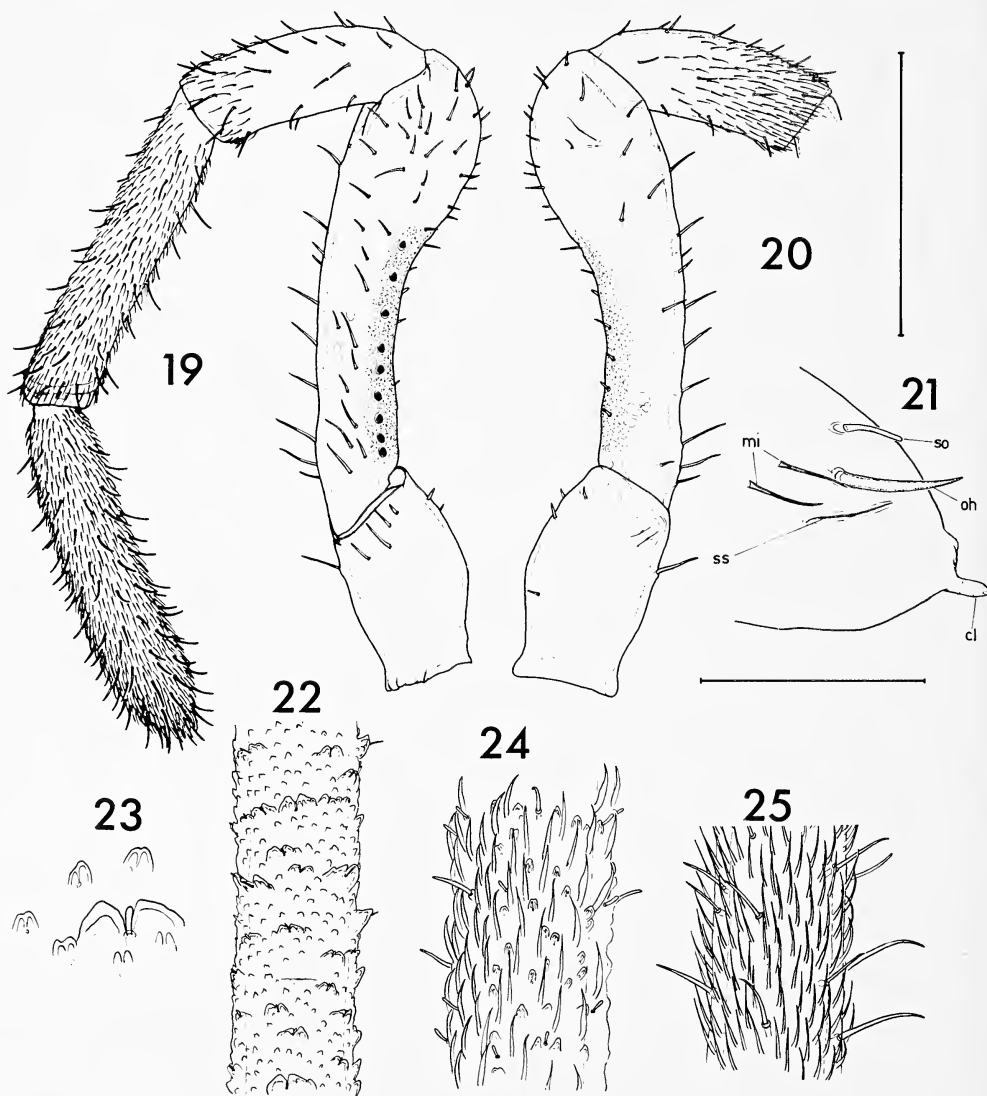
Pedipalpi (Figs. 19-21, 26-28). Coxal endites with finely denticulated cuticle on basal, sclerotized part; their soft distal part with pointed dorsoapical and rounded ventral lobe covered densely with minute papillae, between these scattered small, light colored trichomes, and brushlike groups of basally fused, light brownish trichomes (Fig. 26). Cuticle of free articles smooth. Femora stout, without basal bend, straight in female; slightly curved dorsad in males and thickened in apical part, with a swelling on prolateral side (Figs. 19-20). Patellae to tarsi cylindrical, rather stout. Tarsi with short, straight, peg-shaped claw rudiments somewhat hidden between hairs (Figs. 21, 28). Proximal two-thirds of prolateral sides of femora with rows of broad conical pegs set in basal rings (enlarged setae) in strip of very dark cuticle ("rasp" of stridulating organ). In one female a similar peg was found on the ventral side of the trochanter (Fig. 26). Setae of palpi of ordinary shape, straight or slightly recurved, denser near tip of tarsus. No glandular setae. Dense cover of microtrichia on tarsi, tibiae and patellae: to base of patellae in female (Figs. 26, 27), only apically in male (Figs. 19, 20). For discussion of stridulating organ see Gruber (1969), for eventual glandular function of male palpi see below.

Legs with articles rounded in cross-section. Trochanters with small tubercles on pro- and retrolateral sides. Femora 1 and 3, less so 4, stout and slightly thickened towards apex; the second one slender, cylindrical. Metatarsi thinner than tibiae; second with more or less clearly defined pseudo-articulations in distal part: mostly 2 to 4, only 1 in one male, lacking altogether in one female. Tarsi thin.

Tarsal numbers sometimes difficult to define due to incomplete subdivisions; numbers given here for right/left legs, in parentheses primary subdivisions: Male: 15(13+2)/15 (13+2)—20 or 21 (18 or 19+2)/19 (17+2)—17 or 19 (13 or 15+2+2)/17 (13+2+2)—17 (13+2+2)/18 (14+2+2). Female: 16 (14+2)/16 (14+2)—21 (19+2)/21 (19+2)—18 (14+2+2)/18 (14+2+2)—19 (15+2+2)/20 or 21 (16 or 17+2+2).

Leg sculpture and vestiture: Femora (Figs. 22, 23) with small denticles scattered over surface, larger ones more or less ordered in transverse rows, predominantly on the dorsal side. Small denticles mostly with two, larger ones with several, "cores." Setae of two

types: short, bluntly club-shaped ones, each associated with a double denticle, scattered over surface (Fig. 23), and larger ones in longitudinal rows. Tibiae similar, but denticles more sloping distad, setae longer, especially on second leg. Microtrichia scattered sparingly on ventral surfaces of first and second tibiae, forming a ventroapical wedge-shaped area, more on prolateral side; also a few microtrichia on base of second and middle of first tibia (not found in female). Metatarsi with different types of microsculpture on basal and apical parts (Figs. 24, 25); with transition plane strongly inclined in dorsodistal to



Figs. 19-25.—*Ceratolasma tricantha*, male, morphology of pedipalpi and leg sculpture: 19, right palpus, prolateral view; 20, same, retrolateral view, tibia and tarsus omitted; 21, tarsus apex, retrolateral (claw rudiment and only a few representatives of hair types shown); 22, femur of second right leg, prolateral, middle part, microsculpture; 23, same, detail of denticles; 24, second right metatarsus, prolateral, middle part of basal portion; 25, same article, middle part of distal portion. cl, claw rudiment; mi, microtrichia; oh, ordinary setae; so, solenidion; ss, slit sensillum. Upper scale: 0.5 mm for Figs. 19, 20, 22. Lower scale: 0.2 mm for Figs. 24, 25; 0.1 mm for Figs. 21, 23.

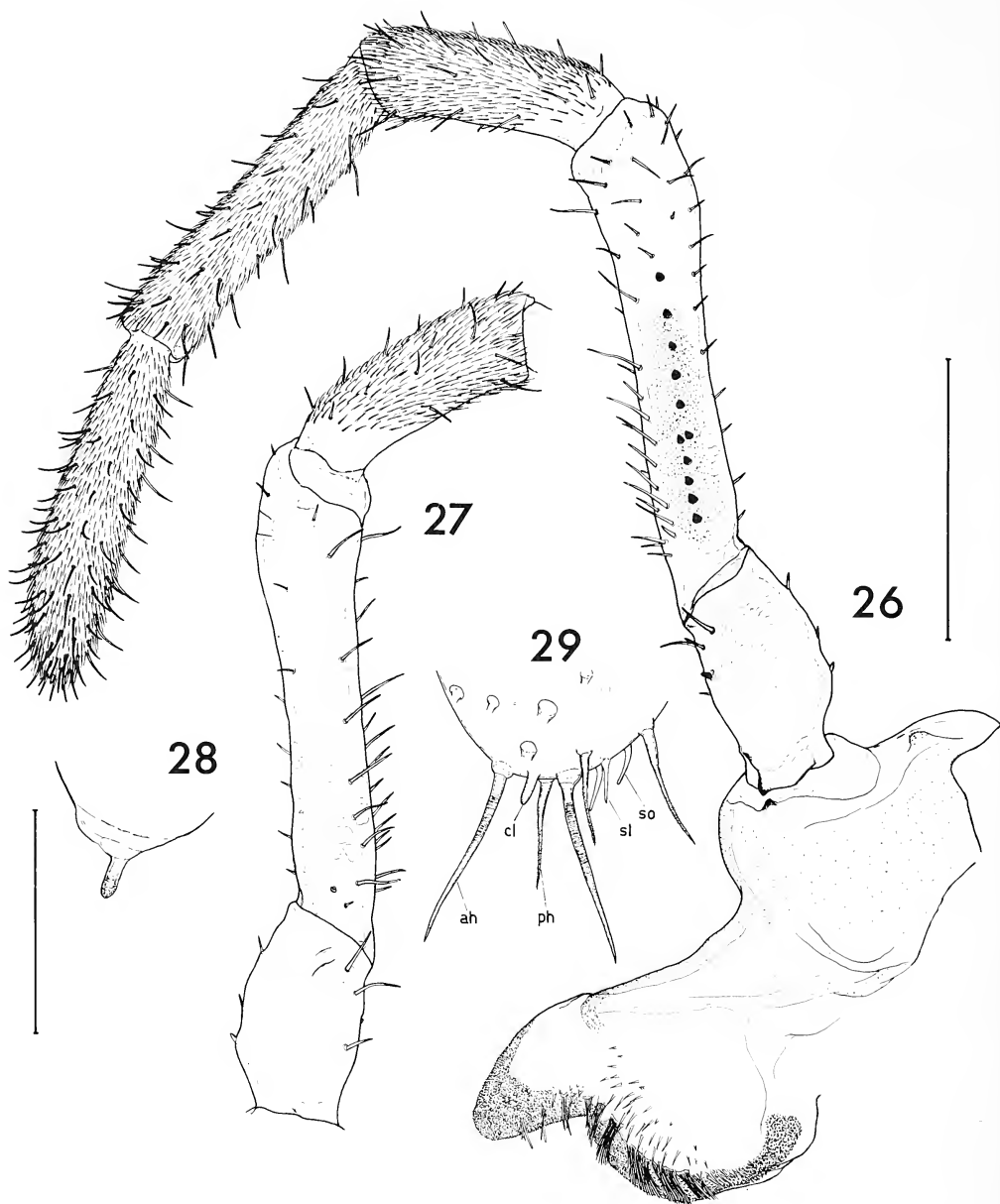
ventrobasal direction. Distal type covers a variable length of the dorsal surface (about the apical third in first, half in second, fifth in third and eighth in fourth metatarsus), it extends farther basad on the ventral side. This apical part with its visibly different pubescence presents a certain similarity to a calcaneus, which is not otherwise demarcated. Sculpture and vestiture of basal portion similar to that of tibia; only basoventrally a few microtrichia (leg 2, see above!), which are thicker, more strongly curved, generally coarser than those of the distal portion; short blunt setae in association with denticles; longer setae blunt. Distal portion with dense cover of microtrichia of slender and hairlike shape; denticles and short setae lacking; longer setae pointed; between other hairs are hair sensilla. Tarsi similar to distal portion of tibia.

Genital morphology: Male: Penis sheath with soft pale cuticle, dorsolateral walls with two brown, sclerotized bands, widening basad and fused into a dorsobasal plate (Figs. 6, 7). Musculature of penis sheath includes four muscle pairs (Figs. 6, 7), which correspond to the description given for *Ischropsalis* by Hansen and Sørensen (1904), with one notable discrepancy (abbreviations used here follow these authors): *mr* and *mp* show subdivision into two fiber bundles; *mf* arises in basal fourth of the penis length in the ventro-median line and runs in dorso-distad direction, parallel to the surface of the penis sheath. Hansen and Sørensen figure a corresponding muscle (*mg*) in *Nemastoma*, but for *Ischyropsalis dispar* (their Fig. IV/18) they describe muscle *mf* as running just in the opposite direction. cursory examination of a penis of *Ischyropsalis hellwigi* showed that the conditions in this species correspond to those in *Ceratolasma*, differences in proportions being neglected. It seems therefore that the differing data in Hansen and Sørensen were caused by an error in orientation, and that the muscle sheathing the basal part of the penis has the same general situation in Ischyropsalidae and Nemastomatidae.

Penis stout (Figs. 8, 9), total length 2.0 mm. Shaft tapering evenly from base to apex, flattened on dorsal and ventral sides, base with small but deep median notch. Cuticle dark brown, with fine transverse wrinkles and even finer longitudinal striations, dorsal side with larger pores. Tendon of muscle short, less than one tenth of shaft length, inserting ventrally on glans base (Fig. 10), on base of dark triangular, tongue-shaped plate, which is surrounded by pale membranous zone (Fig. 6). Glans conical, with numerous short thin setae (Fig. 10), very dark, especially near apex. Stylus thin, extended in penis axis, but flexible at the base, with small ventrolateral hook.

Female: Ovipositor short and stout, slightly depressed ($0.75 \times 0.55 \times 0.40$ mm), Figs. 11, 12. Cuticle soft, pale, wrinkled, with small papillae, especially on the apical portion. Opening cleft equally deep on dorsal and ventral sides, bordered with densely spaced, minute spines (elongated papillae). Setae sparse: a few brownish, stronger ones on low sockets, form an irregular double circle around the base of the furca lobes, without visible dorsoventral asymmetry. Two groups of shorter setae on apices of furca lobes (possibly in a notch of the spine border, but I could not ascertain finer details of the apical structures in my preparation). Vagina with longitudinal folds showing torsion especially basal from receptacles; dorsal and ventral "stiffening rods" distal from receptacles extend near surface of ovipositor. Two extensive glands take most of the space between surface and vagina, their richly branched ducts discharge into vagina near the receptacles (Figs. 13, 14). Seminal receptacles: on each side two short, oval sacs.

Coloration and pattern: The color pattern of the body consists of dark brown, black, amber and strikingly white parts. Pigments, especially the white one, predominantly hypodermal, only dark brown and black sclerotized parts with pigmented cuticle. Cuticle generally amber-hyaline. Membranes without white pigment, but may be underlain by

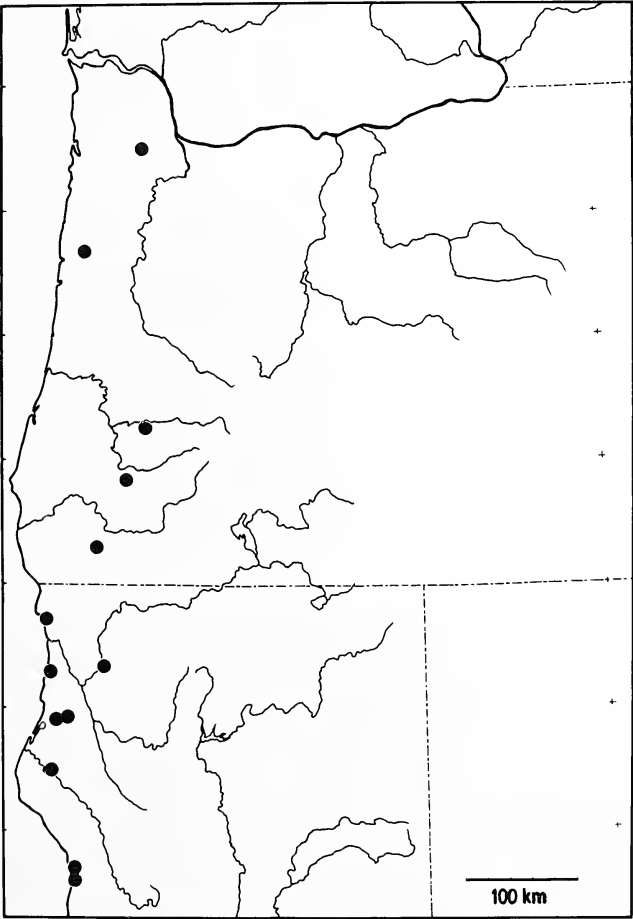


Figs. 26-28.—*Ceratolasma tricantha*, female, morphology of pedipalpi: 26, right palp, prolateral view, coxa with endite shown; 27, same, retrolateral, coxa, tibia and tarsus omitted; 28, tarsus apex, prolateral.

Fig. 29.—*Sabacon* sp. (juvenile specimen from Kittitas Co., Washington): right palp, tarsus apex in retrolateral view (claw rudiment and a few representatives of hair types, some hair bases and two cuticular pores shown). ah, annulated setae; ph, plumose setae; sl, straight, pointed hair sensilla. Right scale: 0.5 mm for Figs. 26, 27. Left scale: 0.1 mm for Figs. 28, 29.

dark pigment. White pigment often in cores of tubercles, spines or denticles, also in cuticle canals without visible overlying sculpture, presenting small starlike figures.

Eye tubercle brown with black eye rings and white spots, median process brown. Carapace with more or less distinct median brown band, dark spot on thoracic segments 1 and 2. Scute areas 1 to 4 with brown saddle, widening caudad, ending abruptly on area 4, the dark color extending to the anterior slopes of the large tubercles, their tips as well as the caudal part of area 4 white. To the sides of this dark median zone follows a paler one: Lateral carapace processes white, anterior portion of lateral pieces white. Large part of the carapace whitish with brown muscle insertions. A semilateral zone of the scute with white areas diminishing in caudal progression due to darker intersegmental bands and brown muscle insertions. Lateral sides of body brown, beginning above rostral side of second coxa, including caudal portion of the lateral pieces. Lateral parts of second thoracic tergite and of scute brown with white spots. Caudal portion of scute (part of area 4 and area 5) and tergites 6 and 7 whitish, sharply distinct from darker anterior



Map 1.—*Ceratolasma tricantha*, recorded distribution: Oregon with parts of Washington and Northern California.

parts, spotted. Lateral parts of free tergites brown. Tergite 8 lighter in middle. Anal operculum whitish, sides with small spots. Parts of tergite 9 brown, lighter towards median side. Anal sternite light brown. Free sternites brown laterally, lighter in middle; spiracular sternite light brown with darker muscle insertions. Coxae pale, darkened distally, apical tubercles white. Coxal endites dark brown. Legs with banding pattern from femur to tibia, indistinct on ventral side. Metatarsi and tarsi brown. Palpi pale, with dark prolateral band on femur; patellae on dorsal side and tarsi darker. Chelicerae pale to light brown, stridulation field and chla fingers dark to black. The color pattern varies in distinctness. Some animals, e.g., the female from Canyonville, are rather pale generally, with dark areas reduced in extent. Also irregular dark mottling occurs, which seems to be no part of a regular pattern.

Measurements (in mm) are tabulated (Tables 1, 2) for the five males and eight females seen.

Juvenile stages: Unknown.

Variation.—Variations of color pattern, number of false articulations of the second metatarsi, and of body measurements are dealt with above and in Table 1. It may be noted that a large part of the differences in body measurements between males and females are due to the expansion of membrane areas in the latter.

Table 1.—Body measurements of *Ceratolasma tricantha* males and females. Values are means in millimeters (for males N = 5, for females N = 8), followed by standard error of mean in parentheses. A, overall body length; B, same, free tergites excepted; C, same, free tergites and anterior processes excepted; D, cephalothorax length, processes included; E, carapace breadth; F, opisthosoma breadth; G, length of second leg femur.

	Males	Females
A	4.76 (.13)	6.39 (.22)
B	4.56 (.12)	6.06 (.44)
C	3.82 (.11)	4.98 (.12)
D	2.42 (.06)	2.60 (.05)
E	2.36 (.07)	2.79 (.04)
F	2.40 (.07)	3.54 (.12)
G	4.26 (.38)	4.26 (.20)

Table 2.—Measurements in millimeters of leg and palpal segments of *Ceratolasma tricantha* specimens described in the text. Legs indicated by Roman numerals, P means pedipalp.

	I	II	III	IV	P
Male (#):					
Femur	2.0	3.3	2.1	3.1	0.84
Patella	0.8	0.9	0.7	0.9	0.43
Tibia	1.2	2.3	1.4	1.4	0.61
Metatarsus	2.0	3.6	2.3	3.8	-
Tarsus	2.3	3.9	2.5	3.1	0.63
Total:	8.3	14.0	9.0	12.8	2.51
Female (#13):					
Femur	2.3	3.8	2.3	3.5	0.90
Patella	1.0	1.0	1.0	1.0	0.46
Tibia	1.3	2.7	1.5	2.1	0.63
Metatarsus	2.3	4.1	2.6	4.3	-
Tarsus	2.3	4.3	2.5	3.1	0.63
Total:	9.2	16.0	9.9	14.1	2.62

Table 3 provides data on the variation in the numbers of tarsal segments in the five males and eight females examined. The specimen numbers are repeated in the section, NEW RECORDS, so that this data may be connected to geographical distribution. The specimens themselves were numbered in order of increasing body size. The values given in Table 3 have been rounded off in case of incomplete subdivisions, these having been considered as full divisions; the numbers in parentheses are values for the distitarsi, when these divisions exceeded two in number. Damaged tarsi are given by “d.” In one case (third leg of female 9) there was pronounced asymmetry in the distitarsi, possibly due to regeneration of a damaged leg. Tarsal numbers are not elevated in males as in many opilionids, on the contrary females of *C. tricantha* tend to have higher values. Three-segmented distitarsi go with the relatively longer legs. The importance of these counts has been questioned in some phalangiid genera (McGhee, in litt.), but because *C. tricantha* is presently the only species of its genus, we have nothing to compare them with. They are presented here because other species might be discovered later.

Geographic variation.—There are too few specimens for well-founded conclusions, but some differences between northern (Oregon) and southern (northern California) animals may be seen. The former tend to have relatively shorter legs and low tarsal segment counts, the latter longer legs and higher counts, but there are exceptions. Shear (in litt.) examined the specimens in the American Museum of Natural History and found that “southern males have the tubercles at the posterior margin of the carapace more coalesced and the major tubercles of the abdomen are higher and more pointed.” Also, “the rasp of the palpal femur tends to have one or two accessory teeth at the base in the Oregon specimens, not in those from California.” He concludes that taxonomic separation seems not warranted at the present moment and that all specimens belong to one species.

Notes.—In one male a small whitish mass of coagulated secretion adheres to the pro-lateral ends of the palp femora. The origin of this secretion is not quite clear. The swelling present in this place bears a few hairs, and its relatively porous cuticle and the opaque tissue underlying it may point to a glandular function, but this could not be ascertained precisely with the methods available. Possibly the secretion may come from the chejiceral glands and only secondarily adhere to the palpi. When folded back in rest, the palpal

Table 3.—Tarsal subdivision counts for five males and eight females of *Ceratolasma tricantha*. For localities of numbered specimens see section “New Records.” Distitarsal subdivision numbers given in parentheses for values other than two; “d” means damaged tarsus.

	Leg I	Leg II	Leg III	Leg IV
Males				
1	15/15	20/19	18/17	17/18
2	17/16	23/22	19/18	22/20
3	20/20(3)	25/26(3)	20/20	21/21
4	17/17	23/24	20/20	21/20
5	17/17	23/23	18/19	19/19
Females				
6	20/19(3)	27/28(3)	22/22(3)	22/21
7	20/19(3)	26(3)/d	20/20	22/22
8	21/20(3)	28/26(3)	23/22	23/23
9	20/19	22/22	20/14(12+2)	22/22
10	19/19(3)	25/23(3)	d/20	22/21(3)
11	19/19(3)	24/24(3)	20/20	21/d
12	15/15	21/21	17/18	19/20
13	16/16	21/21	18/18	19/20

femur apices are situated near the concave surface of the cheliceral glands, so that a transfer of secretion may be possible. Is this an accidental or a normal occurrence? The cheliceral glands of the male play a role in mating, as established in *Ischyropsalis* by Martens (1969b), the gland surface in this form being presented directly to the mouthparts of the female. In *Ceratolasma*, the projecting hood may be an obstacle, and one may speculate if the palpi function as intermediaries in the transfer of the gland products. Naturally, observation of live specimens is required to clarify these points.

A dissected female contained in its distended uterus, which occupied about two thirds of the opisthosoma volume, a hyaline, slightly fibrous and swollen slimy mass, including 35 yellowish eggs of ovoid shape (measuring about 0.6×0.5 to 0.65×0.55 mm). The midgut of the same specimen contained, besides unidentifiable granular material, a few remnants of tracheae and setae, suggesting small arthropods as food.

Ecology.—No detailed data are available. The general type of habitat may be inferred from some collectors' labels. All recorded localities fall into the region of the North West Pacific Moist Coniferous Forest, including a part of the Redwood Belt in California.

Distribution.—See Map 1. Coastal regions of Oregon and Northern California, south to Mendocino County. Records from Washington are significantly absent. The species can be regarded as an element of the Vancouverian fauna (Van Dyke 1919).

New Records.—Specimens examined for this study are numbered; see above under MEASUREMENTS. *Oregon*: Lincoln Co., 7.1 m NW Eddyville, 20 June 1966 (T. Briggs, A. Jung), one male (#4), one female (#9), [CAS]; Douglas Co., Bogus Creek E of Glide, 23 July 1962 (V. Roth), two males (#1, 2) [AMNH, NHMW], 4 mi S Canyonville, 23 August 1959 (V. Roth, W. J. Gertsch), two females (#12, 13) [AMNH, NHMW]; Josephine Co., 2 mi N Selma, 22 August 1959 (V. Roth, W. J. Gertsch), one male [AMNH]. *California*: Del Norte Co., 1.6 mi N of Del Norte Coast Redwoods State Park, 25 June 1966 (A. Jung), one female (#7) [CAS]; Siskiyou Co., 1 mi S of Somesbar, 22 August 1959 (V. Roth, W. J. Gertsch), one male (#5) [AMNH]; Humboldt Co., 18 mi W Willow Creek, 21 August 1959 (V. Roth, W. J. Gertsch), two females (#10, 11) [AMNH], 14 mi N Willow Creek, 21 August 1959 (V. Roth, W. J. Gertsch), two specimens (data from V. Silhavy, not seen), 2.7 mi NW Pepperwood, 25 June 1966 (T. Briggs), one female (#8) [CAS]; Mendocino Co., 1.5 mi S Westport, 19 July 1962 (V. Roth), 3 males, 3 females [AMNH], 4 mi S Rockport, 19 August 1959 (V. Roth, W. J. Gertsch), one male, one female [AMNH].

ACKNOWLEDGEMENTS

For the loan of material I thank the following institutions and individuals: American Museum of Natural History, New York (Dr. W. J. Gertsch), Chicago Natural History Museum (Mr. H. Dybas), and Mr. T. S. Briggs, San Francisco. Further American specimens for comparison have been provided by Drs. A. L. Edgar, Alma, Michigan; H. W. Levi, Cambridge; and W. B. Muchmore, Rochester. Dr. V. Šilhavý, Třebíč, ČSSR, provided data about specimens in his collection; Dr. H. Melichar, Vienna, helped with translation of Japanese papers. Dr. Charles R. McGhee made helpful suggestions. Special thanks are due to Dr. W. A. Shear, Hampden-Sydney College, for perusing an earlier manuscript draft and offering many valuable suggestions, as well as for data about specimens not seen by me. Dr. Shear also edited the final copy of the manuscript and read the proofs helping me avoid loss of time due to the Transatlantic mails.

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**TAXONOMIC AND NATURAL HISTORY NOTES ON
PHRUROLITHUS FRATRELLUS GERTSCH
(ARANEAE: CLUBIONIDAE)**

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ABSTRACT

Phrurolithus fratellus Gertsch and *P. britcheri* Petrunkevitch are similar species characterized by peculiar, asymmetrical epigyna. This paper redescribes *P. fratellus*, compares it with *P. britcheri*, and presents data on the natural history of the former. *P. fratellus* differs from *P. britcheri* by its smaller size, flatter carapace, and relatively larger eyes. These species are difficult to separate by epigynal characters. Specimens of both species may have either copulatory tube opening anterior to the other on the mid-ventral line. Pitfall collections indicate *P. fratellus* is a species of field and second growth habitats. Males were collected from 17 April until the week of 17 July; females were collected from 12 June until the week of 25 September. A single male, collected between 23 and 30 October, suggests males overwinter as adults. Fluctuations in weekly collections suggest that this species is more active when the moon is waxing or waning.

INTRODUCTION

There are two species of clubionid spiders in eastern North America characterized by peculiar, asymmetrical epigyna. Perhaps due to their small size these species remain relatively unknown. During a study of spider ecology in central Ohio (Penniman, 1975) a series of one of these was collected and originally identified as *Phrurolithus britcheri* Petrunkevitch, 1910. There is also a very similar form *P. fratellus* Gertsch, 1935, for which the male was described by Barrows and Ivie (1942). I suspected that these were synonymous, but further study revealed that *P. britcheri* and *P. fratellus* are distinct species and that my original collection was of *P. fratellus*. (According to Dondale and Redner [pers. comm.] American species of *Phrurolithus* belong in *Scotinella* Banks, 1911, and *P. britcheri* is a senior synonym of *S. pallida* Banks, 1911, the type species of *Scotinella*. Since I have not seen the type of *S. pallida* or specimens of *P. festivus* C. L. Koch, the type of *Phrurolithus*, I think it would be premature to use the names in combination with *Scotinella* at this time.)

The purpose of this paper is to clarify the identity of these confusing species, to provide a complete description of *P. fratellus*, and to present data on the natural history of this species.

METHODS

Specimens of *P. fratrellus* were collected in Sharon Woods Metropolitan Park just north of Columbus, Franklin Co., Ohio, from 17 April to 6 November 1973. Twenty-one pitfall traps were placed in each of three habitats, a field, a second growth area, and a wood. Each trap consisted of a 16-oz. cottage cheese carton, containing about 30 ml of ethylene glycol, set in the ground with the rim flush with the soil surface. Traps were left in place for periods of one week, then removed, replaced with clean traps, and returned to the lab for sorting. Spiders collected were preserved in 70% alcohol and labeled to indicate week and habitat.

The types of both species were borrowed from the American Museum of Natural History, New York. Six additional specimens of *P. britcheri* and one of *P. fratrellus* were obtained on loan from the Canadian National Collection, Ottawa, Ontario.

Table 1.—Measurements in mm of *P. fratrellus* and *P. britcheri*. Mean \pm one standard deviation; levels of significance between females of the two species are given by: n.s.—not significant, *— $P < .05$, ***— $P < .001$, blank—not calculated (Student's *t*, one-tailed test). Note that measurements of *P. britcheri* are significantly greater than those of *P. fratrellus*, except that the eyes of *P. fratrellus* are larger or there is no difference.

Measurement	<i>P. fratrellus</i> ♀♀		<i>P. britcheri</i> ♀♀		sign.	<i>P. fratrellus</i> ♂♂
	holotype	OH.and Ont. n=19	holotype	Ont. n=6		Ohio n=20
carapace l.	.75	.83 \pm .018	.93	.97 \pm .038	***	.80 \pm .021
carapace w.	.61	.69 \pm .017	.85	.81 \pm .033	***	.66 \pm .021
carapace ht.	.24	.27 \pm .037	.42	.35 \pm .053	***	.26 \pm .029
front height	.05	.07 \pm .006	.09	.08 \pm .000		.08 \pm .002
chelicera l.	.26	.28 \pm .017	.37	.37 \pm .024	***	.27 \pm .013
AME diam.	.05	.05 \pm .007	.04	.05 \pm .008	n.s.	.05 \pm .005
ALE diam.	.05	.06 \pm .008	.04	.05 \pm .005	*	.07 \pm .007
PME diam.	.06	.07 \pm .007	.05	.05 \pm .009	***	.08 \pm .006
PLE diam.	.05	.06 \pm .007	.04	.04 \pm .005	***	.06 \pm .009
sternum l.	.48	.52 \pm .018	.62	.56 \pm .023	***	.48 \pm .015
sternum w.	.47	.52 \pm .011	.61	.59 \pm .018	***	.48 \pm .016
labium l.	.09	.09 \pm .005	.12	.12 \pm .012		.10 \pm .009
labium w.	.11	.14 \pm .007	.19	.17 \pm .007		.13 \pm .003
endite l.	.21	.24 \pm .013	.30	.29 \pm .010		.24 \pm .009
femur I	.61	.69 \pm .018	.90	.87 \pm .038	***	.65 \pm .025
pat + tib. I	.87	.89 \pm .022	1.21	1.13 \pm .054	***	.83 \pm .032
m'tarsus I	.57	.58 \pm .017	.83	.75 \pm .036		.55 \pm .022
tarsus I	.38	.40 \pm .011	.50	.46 \pm .014		.36 \pm .017
femur II	.55	.60 \pm .020	.87	.79 \pm .036	***	.56 \pm .022
pat + tib. II	.65	.71 \pm .022	1.02	.93 \pm .039	***	.65 \pm .025
m'tarsus II	.43	.49 \pm .018	.71	.65 \pm .016		.46 \pm .016
tarsus II	.35	.38 \pm .012	.48	.46 \pm .028		.35 \pm .019
femur III	.46	.50 \pm .024		.68 \pm .032		.47 \pm .021
pat + tib. III	.55	.59 \pm .023		.78 \pm .027		.56 \pm .024
m'tarsus III	.40	.44 \pm .025		.62 \pm .027		.43 \pm .020
tarsus III	.34	.38 \pm .022		.47 \pm .026		.34 \pm .021
femur IV	.68	.72 \pm .025	.93	.90 \pm .028	***	.68 \pm .029
pat + tib. IV	.84	.89 \pm .031	1.10	1.07 \pm .044	***	.82 \pm .030
m'tarsus IV	.67	.69 \pm .028	.84	.83 \pm .038		.65 \pm .028
tarsus IV	.47	.51 \pm .018	.60	.58 \pm .022		.47 \pm .025

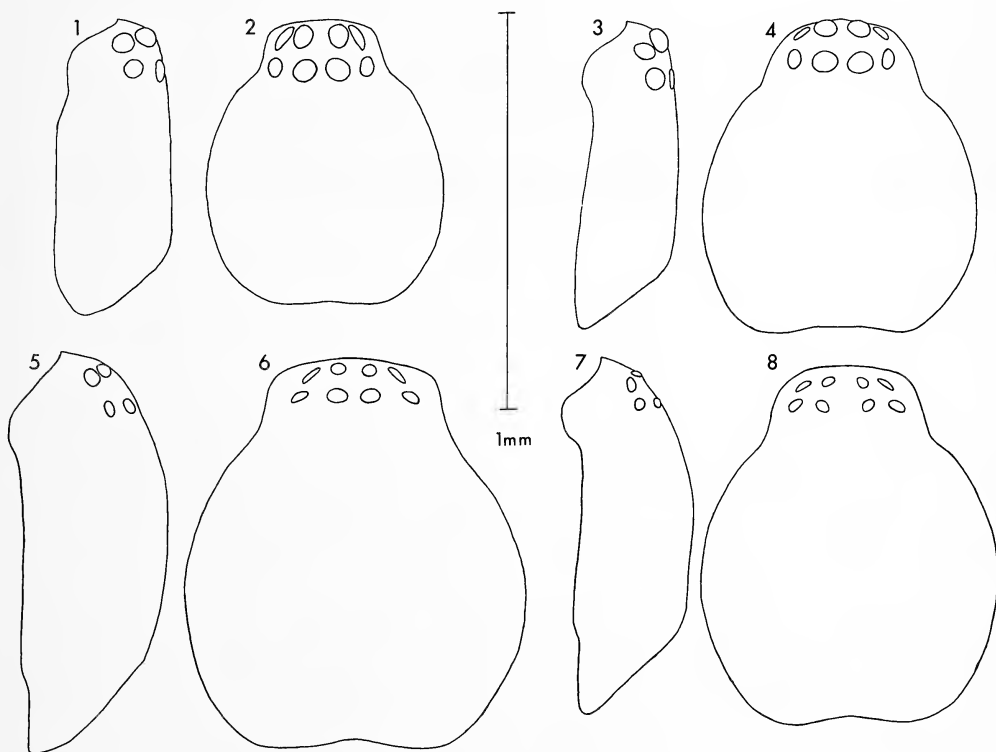
All measurements and drawings of carapaces and epigyna were made at 90X with an American Optical stereo-dissecting microscope fitted with an ocular micrometer or drawing reticule as appropriate. SEM photomicrographs were made with the Hitachi SEM in the College of Biological Sciences, The Ohio State University.

TAXONOMY

Phrurolithus fratrellus Gertsch 1935:6 (Holotype female from Texas, Bell Co., Belton, in AMNH, examined). Barrows and Ivie 1942:20-21 (Male from Ohio, Franklin Co., Columbus, in University of Utah Collection housed at AMNH, missing).

Female.—The description of *P. fratrellus* by Gertsch is good, but, since it was based on a single specimen, does not consider variation; in fact, the type is the smallest female I have seen (Table 1).

Carapace.—Somewhat flattened in lateral view (Figs. 1, 3). Ground color amber, margins a darker brownish-gray; central light area irregularly shaped with a trapezoidal dark blotch within. Ocular area black. Surface sparsely covered with fine setae. Anterior eye row slightly procurved, medians dark, laterals may appear dark or pearly white. Posterior row also slightly procurved, the eyes white or pearly white.



Figs. 1-8.—Carapaces of *Phrurolithus* spp. females. 1-2, *P. fratrellus* holotype: 1, lateral view; 2, dorsal view. 3-4, *P. fratrellus*, Ohio, Franklin Co., 4-11 Sept. 1973 in field: 3, lateral view; 4, dorsal view. 5-6, *P. britcheri* holotype, New York, Onondaga Co.: 5, lateral view; 6, dorsal view. 7-8, *P. britcheri*, Ontario, Carleton Co., 12 May 1974: 7, lateral view; 8, dorsal view.

Chelicerae—Amber, concolorous with lighter parts of carapace. One macroseta on anterio-medial margin about one third the proximal to distal length of paturon. Two rows of fine setae above each fang and an oblique row of fine setae on posterior surface. No promarginal teeth, retromargin with two minute teeth.

Sternum—Amber, darker around edges due to thicker sclerotization. Extends posteriorly between coxae IV where it is rounded. Surface sparsely covered with fine setae.

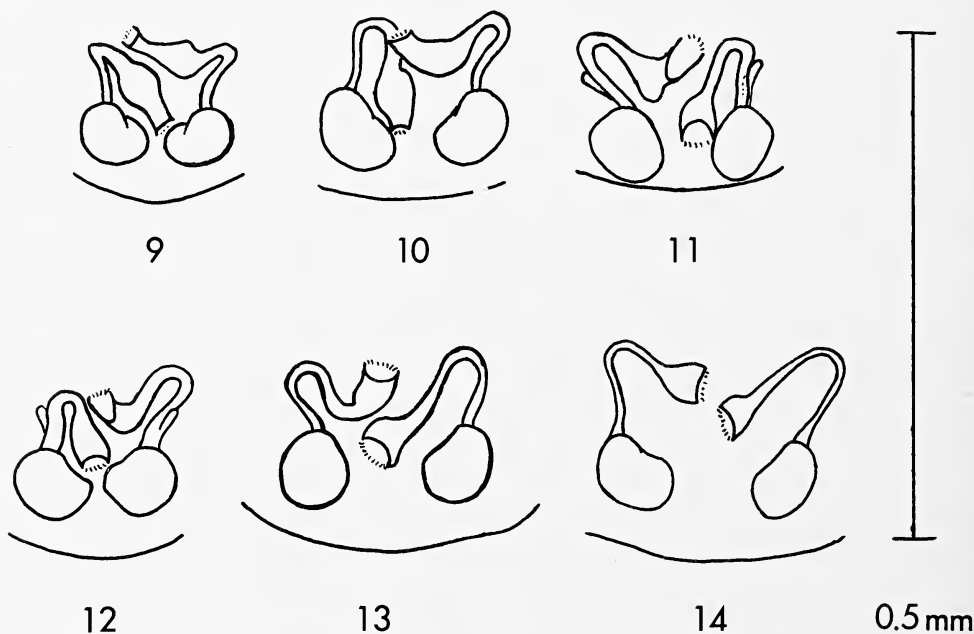
Labium—Center amber, darker at posterior margin and corners; anterior margin white with two tufts of setae.

Pedipalps—Endites concolorous with sternum except at proximal medial corners and distal margins where they are more thickly sclerotized; distal medial corners white and scopulate; ventral surfaces with a few setae. Distal segments yellowish-brown and more densely clothed with setae; femur with a dorsal macroseta; patella and tibia with one macroseta each on prolateral faces; tibia with a dorsal macroseta; tarsus with a claw.

Legs—All segments amber. Macrosetae as follows: femur I with two prolateral macrosetae in distal half; tibia I with five pairs of ventral macrosetae; tibia II with nine ventral macrosetae; metatarsi I and II with seven macrosetae each. Trichobothria present on tibiae, metatarsi, and tarsi of all legs.

Abdomen—Dorsum light gray with two white chevrons and traces of two more; a white spot dorsal to anus. Venter white. Six spinnerets pale yellow to white.

Epigynum—Surface pale yellow. Two spermathecae anterior to epigastric furrow. Two openings in mid-ventral line, each connected to a spermatheca by a curved copulatory tube. Either opening may be connected to either spermatheca (Figs. 9-12).



Figs. 9-14.—Epigyna of *Phrurolithus* spp., ventral views. 9-12, *P. fratrellus*: 9, holotype, “left-tubed”; 10, Ohio, Franklin Co., 19-26 June 1973, “left-tubed”; 11, same loc. 4-11 Sept. 1973, “right-tubed”; 12, same loc. 11-18 Sept. 1973, “left-tubed.” 13-14, *P. britcheri*: 13, holotype, “right-tubed”; 14, Ontario, Carleton Co., 12 May 1974, “right-tubed.”

Male.—The description of this sex by Barrows and Ivie (1942) is extremely scanty. I have not seen their specimen, but their drawings of the palp suggest that they did have this species despite a discrepancy between their figures and mine in the shape of the embolus (Fig. 16).

Carapace—Amber, similar to female but with less dark pattern. Eyes as in female.

Chelicerae—As in female.

Sternum—As in female.

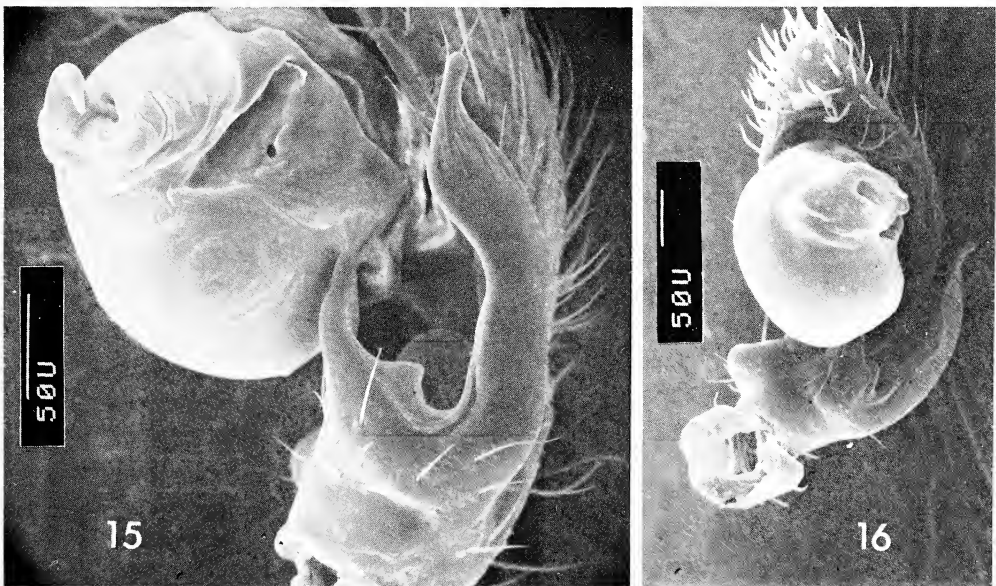
Labium—As in female.

Pedipalps—Endites as in female. Distal segments amber and more densely clothed with small setae, no macrosetae. Femur $0.23 \pm .01$ mm long with a ventral, retrolaterally pointing, hooked apophysis as in other members of the genus. Tibia (Fig. 15) $0.16 \pm .02$ mm long with two brown retrolateral apophyses; the ventral one $0.11 \pm .02$ mm long and paddle-shaped; the dorsal one $0.23 \pm .01$ mm long and complexly curved and twisted. A small toothlike point present in the bight between the two apophyses. Bulb sub-spherical, tegulum amber, the apical portion darker. An internal sperm duct visible through the tegulum in some specimens. Embolus amber and hook shaped. Cymbium $0.38 \pm .01$ mm long with a cluster of stout setae at the distal margin of the alveolus against which the embolus rests in the unexpanded palp (Fig. 16).

Legs—As in female.

Abdomen—Dorsal scutum covers anterior three-fourths; grayish amber in scutal area with two or three amber chevrons and a posterior white spot. Sides gray, venter whitish. An amber scutum anterior to epigastric furrow. Spinnerets grayish-amber.

Diagnosis.—*P. fratrellus* is very similar to *P. britcheri*. It can be separated from the latter by its smaller size, flatter carapace, and relatively larger eyes (Table 1, Figs. 1-8). The few *P. britcheri* I have seen all lack dark pigments and the legs tend to be relatively longer. The only epigynal character that will separate these species is the presence of



Figs. 15-16.—*P. fratrellus* males. 15, palpal tibia and tegulum, retrolateral view, Ohio, Franklin Co., 1-8 May 1973 in second growth. 16, palpal tibia and cymbium, ventral view, same loc., 8-15 May 1973 in field. Scale lines are 50 microns.

pouches arising from the spermathecal ends of the copulatory tubes (Figs. 11, 12), which are difficult to see even in cleared specimens. Three *P. britcheri* from Ontario, Carleton Co., Fitzroy Twp. have simpler copulatory tubes than other females I have seen (Fig. 14).

Since the male of *P. britcheri* remains unknown, I can make no comment on its separation from male *P. fratrellus*. I would expect the males to differ in the same features that distinguish females.

DESCRIPTION OF THE STUDY AREA

In 1973 the field had been out of agriculture about 8-10 years. Goldenrod (*Solidago* sp.) and grasses (Gramineae) were the dominant plants and their dead stems and leaves made up most of the litter. Thistles (*Cirsium* spp.), yarrow (*Achillea* sp.), and raspberry (*Rubus* sp.) were also common. The mustard, *Barbarea* sp., was conspicuous in the spring, but by mid-summer only dead stems remained. There were numerous seedlings and saplings of maples (*Acer* spp.), hawthorne (*Crataegus* spp.), apple (*Malus* sp.), and grape (*Vitis* sp.).

The second growth area had relatively less goldenrod and more grasses and poison ivy (*Rhus radicans*) than the field. However, the most conspicuous plants were seedlings and saplings of elm (*Ulmus* sp.) and ash (*Fraxinus* sp.) up to 6 m and 7 m tall respectively. Less important saplings included maples, dogwood (*Cornus* sp.), hawthorne, and pin cherry (*Prunus* sp.). Moss covered most of the ground at two collecting stations; other

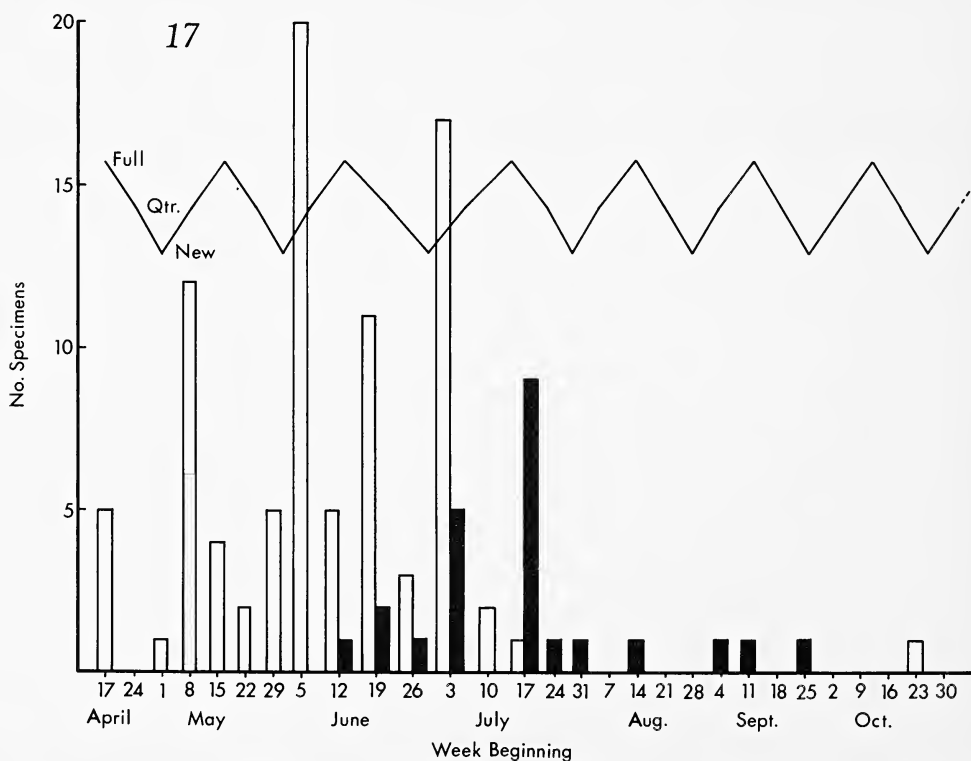


Fig. 17.—Seasonal distribution of pitfall captures of *P. fratrellus* adults. Open bars—males; black bars—females. Zigzag line represents phases of the moon.

plants contributing to the litter were cinquefoil (*Potentilla* sp.), raspberry, yarrow, and basal rosettes of a composite (probably *Heiracium* sp.).

The wood was dominated by very large trees, mostly beech (*Fagus grandifolia*), but including black walnut (*Juglans nigra*), ash, and box elder (*Acer negundo*). A few sycamores (*Platanus occidentalis*) and oaks (*Quercus* sp.) were located at the wood's edge. Smaller trees were hornbeam and hop hornbeam (*Carpinus caroliniana* and *Ostrya virginiana* respectively), buckeye (*Aesculus glabra*), and spicebush (*Lindera benzoin*). Most of the litter layer was beech leaves with a few leaves from other trees. The herbaceous plants, most conspicuous in the spring, included bedstraw (*Galium* sp.), dutchman's breeches (*Dicentra* sp.), wild ginger (*Asarum canadense*), violets (*Viola* spp.), nettles (*Urtica* sp.), Virginia creeper (*Parthenocissus* sp.), and bloodroot (*Sanguinaria canadensis*).

NATURAL HISTORY

P. fratrellus and *P. britcheri* are unusual among spiders in having asymmetrical epigyna. Some specimens have the right copulatory tube leading to the anterior opening ("right-tubed") and others have the left tube leading to the anterior opening ("left-tubed"). This mirror image situation could be a mechanism of genetic isolation, if males were able to mate only with "left-tubed" or "right-tubed" females. It seems that this is not the case, however. Males are equipped with two palps which are mirror images of each other. Even if a male is unable to use both palps in mating due to the asymmetry of the female, he could use one or the other regardless of whether the female is left or right "tubed." There is no *a priori* reason to think that males are not completely ambidextrous. Of the 24 female *P. fratrellus* collected during this study 15 are "right-tubed" and nine are "left-tubed" (not significantly different from 1:1, $P > .10$, χ^2). Of the seven *P. britcheri* seen, four are "right-tubed," three "left-tubed."

Of 114 *P. fratrellus* collected 74 (65%) were taken in the field, 38 (33%) were trapped in the second growth, and a male and a female were taken in the woods. Thus this is a species of early to mid-successional habitats.

Males occurred in the traps from 17 April until the week of 17 July (Fig. 17). Females first appeared the week of 12 June and persisted until the week of 25 September. A single male trapped between 23 and 30 October and the fact that males were mature when trapping began suggests that males, at least, overwinter as adults. Maturation of males before females was a common pattern among other species collected at the same time (Penniman 1975:62).

Numbers trapped fluctuated sharply from week to week; the fluctuations seemed to follow the lunar cycle, more spiders being trapped while the moon was waxing or waning than when it was new or full (Fig. 17). Because pitfall catches are dependent on activity, this suggests a particular activity pattern for this species. The significance of such a wax-wane pattern is unclear.

Barrows and Ivie (1942) remarked that their *P. fratrellus* male was collected in an ant nest, and Kaston (1948:392) reported a female *P. britcheri* collected with "red" ants. Three female *P. britcheri* from Ontario, Carleton Co., Fitzroy Twp., were collected under a rock with "yellow ants" on 12 May 1974. Unfortunately, ants from my pitfalls were not saved, so I have no evidence regarding such an association. Since ants and *Phrurolithus* spp. may be cryptozoic, the relationship between them may be coincidental

rather than symbiotic. Investigations of an association with ants, of activity patterns related to the lunar cycle, or of mating behavior of *P. fratrellus* in light of its asymmetrical epigynum could prove rewarding.

ACKNOWLEDGMENTS

I am deeply indebted to Charles Dondale and Mr. James Redner for their suggestions which kept me on the right track at a crucial stage of this work, and for specimens of *P. britcheri* which they were kind enough to loan. I am indebted also to Dr. Norman Platnick, American Museum of Natural History, for the loan of the types of *P. britcheri* and *P. fratrellus* and for his review of the manuscript. Dr. B. J. Kaston carefully reviewed the manuscript and Drs. Dondale and George Uetz read a rough draft. Dr. Barry Valentine provided valuable advice and assistance including helping me to gain access to the scanning electron microscope. Mr. Edward Hutchins and his staff of the Columbus and Franklin County Metropolitan Parks were helpful in providing the study site where *P. fratrellus* was collected.

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THE SPIDER GENUS *POULTONELLA* (ARANEAE: SALTICIDAE)

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ABSTRACT

The rare North American salticid genus *Poultonella* is reviewed and diagnosed. *Poultonella* is removed from Fissidentati and placed in Unidentati, subfamily Dendryphantinae. The female of *P. alboimmaculata* is redescribed and the male of the species is described for the first time. The natural history of *P. alboimmaculata*, in north-central Texas, is discussed. *P. nuesensis*, new species, is described from Mustang Island on the Texas coast.

INTRODUCTION

The validity of the salticid genus *Poultonella* has been questioned because of scarcity of material and lack of male specimens. This paper presents a new description of *Poultonella alboimmaculata*, including for the first time the male, and supplements the genus by description of a new species, *P. nuesensis*. Although Peckham and Peckham (1909) placed *Poultonella* in Simon's group Fissidentati (lower margin of the chelicera with a compound tooth), we found that all specimens, including the holotype of *P. alboimmaculata*, belong to Unidentati (those with a single tooth on the lower margin). Petrunkevitch (1928), also placed *Poultonella* in the Fissidentati, in his subfamily Maeviinae. Based upon the structure of the genitalia, *Poultonella* is best placed in Dendryphantinae.

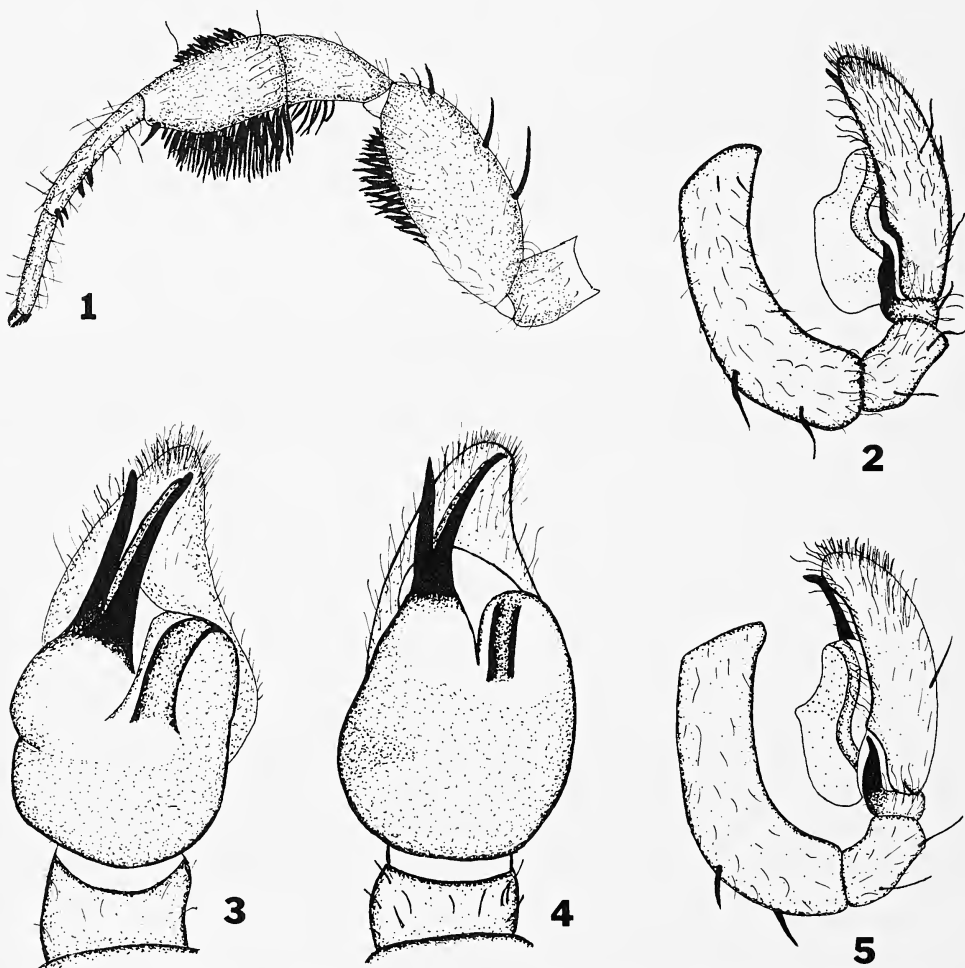
Poultonella Peckham and Peckham

Poultonella Peckham and Peckham 1909:576. Type-species (by monotypy): *Attus alboimmaculatus* Peckham and Peckham; Banks 1910:66; Petrunkevitch 1911:696, 1928:191; Crosby and Bishop 1928:1073; Bonnet 1958:3767; Prószyński 1976:18.

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Diagnosis.—Examination of available material has convinced us that *Poultonella* is a valid genus separable from other salticid genera by the following characters: length of tibia plus patella of legs IV longer than III; ocular area, occupying one half carapace length, wider (4/5) behind, with small eyes nearer first row than third; tibia I with one or two ventral spines. *Poultonella* can be distinguished from *Bianor*, *Sassacus* and *Agassa* by the presence of heavy hair tufts on leg I; palpal embolus straight and bifid; guide of epigynum well developed and originating posteriad.

Description.—Medium large (3-5mm) spiders with the carapace slightly longer than wide. Anterior median eyes one-third their radius apart, twice diameter of anterior and posterior laterals; posterior median eyes one-fifth diameter of anterior median eyes. Cheliceral fang furrow with a simple retromarginal tooth. Endites three times as long as wide, expanded anteriorly, scopulated, males with distolateral apophysis. Labium one-half as long as wide, base equal to or slightly less than anterior width of sternum. Legs of moderate length, formula 1:4:2:3 in males, 4:1:2:3 or 4:1:3:2 in females, first pair with



Figs. 1-5.—*Poultonella alboimmaculata* (Peckham and Peckham): 1, male leg I, retrolateral view; 2, left palp, retrolateral view; 3, left palp, ventral view. *P. nuecesensis*, new species; 4, left palp, ventral view; 5, left palp retrolateral view.

femur, patella, and tibia possessing tufts of hair and greatly expanded (Fig. 1). Strong spines on dorsum of femora, 1-1-2 or 1-1-1; tibia I (ventral), 0-1-1 or 0-0-1; metatarsus (ventral) I 0-1-2, II 0-0-2, III and IV 0-0-4.

Poultonella alboimmaculata (Peckham and Peckham)

Figs. 1-3, 6, 7, 10

Attus albo-immaculatus Peckham and Peckham 1883:24-25, pl. II, fig. 19, pl. III, fig. 19a (Female holotype, from Iowa, in Museum of Comparative Zoology, examined).

Dendryphantes albo-immaculatus, Peckham and Peckham 1888:41, p. III, fig. 29; Marx 1890:570 (*alboimaculatus*, sic.), 1892:161 (*albomaculatus*, sic.).

Poultonella alboimmaculatus, Peckham and Peckham 1909:576-577; Banks 1910:66 (*alboimaculatus*, sic.).

Poultonella alboimmaculata, Petrunkevitch 1911:696, 1928:191; Crosby and Bishop 1928:1073; Bonnet 1958:3767-3768 (*albimmaculata*, suggested emendation).

Description.—Female: Holotype from Iowa missing five legs but important legs I (right) and IV (both) present. Epigynum (Fig. 6). Spermathecae of epigynum (Fig. 7) of female from Wichita County, Texas (Museum of Comparative Zoology) similar to holotype. Fresh specimens with white, spatulate hairs, in some places resembling scales, densely covering dorsal and lateral aspects of cephalothorax and entire abdomen. Anterior margin of abdomen and posterior margin of cephalothorax with rows of long, slender, white hairs. Sternum dark brown with scattered white, spatulate hairs; posterior portion with several long, slender, white hairs. Labium dark brown. Coxae and trochanters light brown with several long, white hairs. Spinnerets black. Femur I dark brown, covered with white, spatulate hairs; these heavily concentrated on the distodorsal portion to produce a white band. Dorsum of patella I with white, spatulate hair bands on ends. Tibia I distodorsal surface with a light band of white hairs. Lateral surfaces of metatarsus and tarsus of leg I with ventral band of white, spatulate hairs. Legs II-IV marked as leg I except femora covered with many, spatulate, white hairs. Hairs confined to lateral surfaces on patella and tibia, producing longitudinal stripes. Metatarsus and tarsus without spatulate hairs.

Measurements in millimeters of five mature females; range followed by mean in parentheses. Total length, 3.13-4.75 (4.04); carapace length, 1.65-1.80 (1.71); carapace width, 1.21-1.34 (1.28); leg I length, 2.61-3.02 (2.75); leg II length, 2.19-2.30 (2.24); leg III length, 2.23-2.41 (2.30); leg IV length, 3.31-3.03 (3.14).

Male: Color and markings like those of female. Number of hairs in banding of legs II-IV reduced. Sternum covered with few spatulate, white hairs; margins with long, white hairs reduced near labium. Palpi as in Figs. 2 and 3.

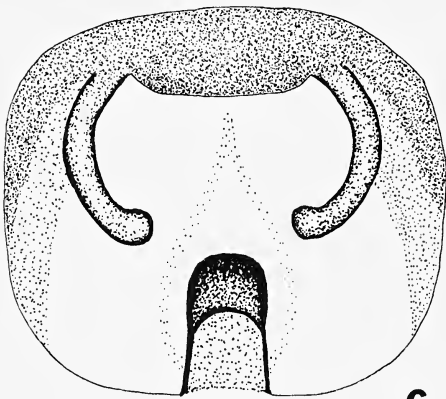
Measurements in millimeters of six mature males; the range followed by mean in parentheses. Total length, 2.95-4.38 (3.47); carapace length, 1.60-2.08 (1.77); carapace width, 1.15-1.44 (1.29); leg I length, 3.06-4.67 (3.75); leg II length, 2.47-3.01 (2.63); leg III length, 2.10-3.09 (2.54); leg IV length, 2.75-3.91 (3.25).

Range.—North-central and western Texas, Iowa and New York (Fig. 10).

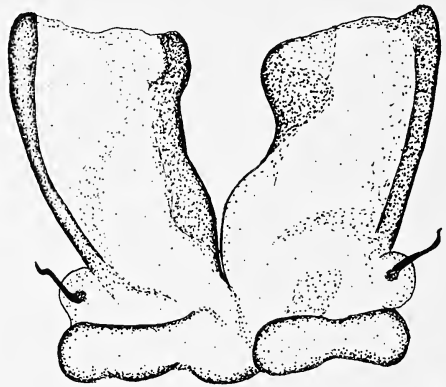
Natural History.—Specimens of *Poultonella alboimmaculata* have been taken during all months except March, November and December. Adult males are available from late January to mid August with females maturing later, mid May until early September.

Several hibernating chambers were located beneath the bark of mesquite trees (*Prosopis juliflora*). Some adult males were found with immatures in the same hibernating chambers. May appears to be the peak period of activity of this species. In May some adults move away from the *Prosopis* and seek food on flowering plants: *Asclepias oenotheroides* (Asclepiadaceae), *Bromus tectorum* (Gramineae), *Gaillardia pulchella* (Compositae), *Helianthus* sp. (Compositae) and *Thelesperma* sp. (Compositae). Although primarily diurnal, a single, adult male was taken while ballooning at 3:00 a.m. in late May. Carpenter (1972) reported *P. alboimmaculata* from sparse sage and salt cedar.

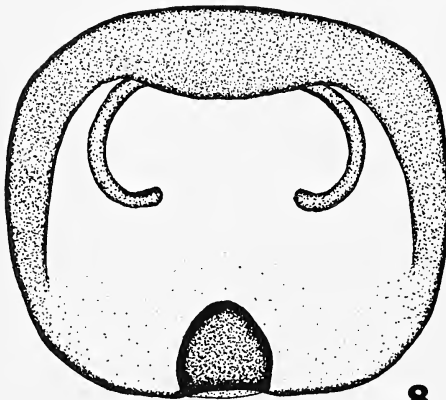
Material Examined.—All specimens are at Midwestern State University unless otherwise indicated. *Texas. Wichita County:* Wichita Falls; four males, two females, 21 immatures (May 1977, G. E. Bastin), one male, two immatures (28 Jan. 1977, G. E. Bastin), one male (22 May 1976, H. S. Zaltsberg), one immature (10 Feb. 1973, L. Pierce), one female, one immature (24 July 1977, J. C. Cokendolpher), 4.8 km NW Iowa Park; two immatures (28 Sept. 1968, R. Carpenter), 16 km S. Electra; one female (8 Sept. 1968, R. M. Carpenter), 14.4 km WSW Burkburnett, one female (14 May 1977, J. C. Cokendolpher, MCZ), Bridgetown, one female (25 June 1977, J. C. Cokendolpher, AMNH), 3.2 km SSW. Burkburnett, one male (15 April 1977, J. C. Cokendolpher), one male (28 May



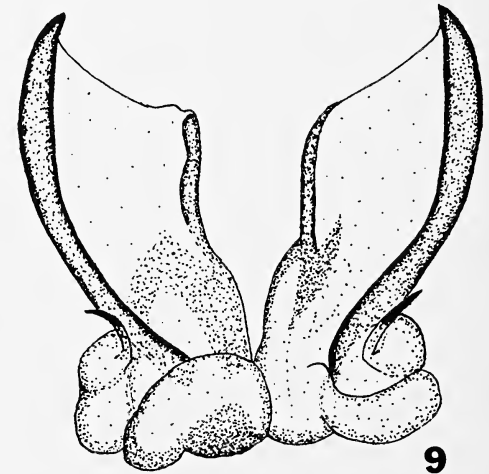
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9

Figs. 6-9.—*Poultonella alboimmaculata* (Peckham and Peckham): 6, epigynum, ventral view; 7, spermathecae, dorsal view. *P. nuecesensis*, new species; 8, epigynum, ventral view; 9, spermathecae, dorsal view.

1977, J. C. Cokendolpher, AMNH), one female, two immatures (23 July 1977, J. C. Cokendolpher), one immature (17 Oct. 1975, J. C. Cokendolpher), Burkburnett; one male, one female (20 Aug. 1968, R. M. Carpenter), 14.7 km E Burkburnett; two females (14 May 1977, J. C. Cokendolpher), 4.8 km SSW Friberg Cooper Community; one male (14 May 1977, J. C. Cokendolpher, MCZ). *Donely County*: 11.2 km N Clarendon, one female (19 June 1976, K. Douglass). Iowa. No specific locality, one female (1883, G. W. Peckham, MCZ).

Poultonella nuecesensis, new species

Figs. 4, 5, 8, 9, 10

Types.—Male holotype from Port Aransas (27°24'N. 97°04'W.), Mustang Island, Nueces County, Texas (14 August 1977, W. W. Dalquest and R. M. Carpenter) deposited in the American Museum of Natural History. Female paratype from same locality (9 April 1977, G. E. Bastin), same depository. Two male paratypes: (9 April 1977, D. Holub) in the Museum of Comparative Zoology, (14 August 1977, W. W. Dalquest and R. M. Carpenter) at Midwestern State University. All specimens taken at an altitude of 7 m.

Etymology.—The specific name is derived from Nueces County, Texas, where the original material was collected.

Diagnosis.—*Poultonella nuecesensis* is readily separated from *P. alboimmaculata*, the only other member of the genus, by details of the genitalia, color, and reduction of spatulate hairs: *P. nuecesensis* is orange-red in color whereas *P. alboimmaculata* is brownish-black. *P. nuecesensis* has few spatulate hairs, particularly on the dorsum of the cephalothorax and on the legs. *P. alboimmaculata* has the abdomen and cephalothorax densely covered with white, spatulate hairs. The palpi of *P. nuecesensis* differs from those of *P. alboimmaculata* by the shorter conductor length, thinner and less convoluted

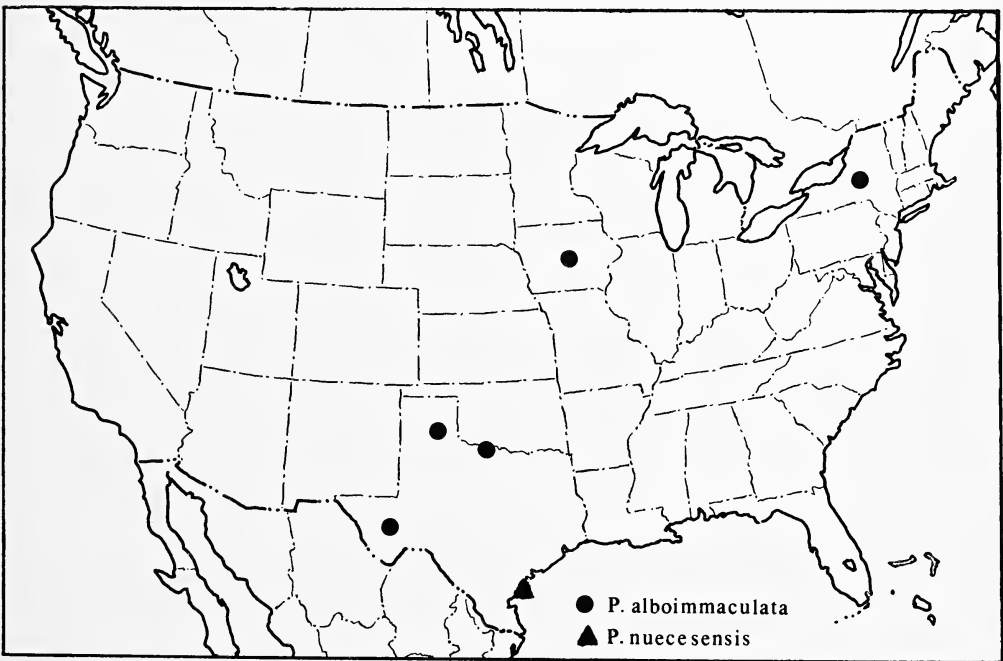


Fig. 10.—Distributions of *Poultonella alboimmaculata* (Peckham and Peckham) and *P. nuecesensis*, new species.

receptaculum seminis, and less bulbous shape of the tegulum. The epigynum of *P. nuecesensis* differs from *P. alboimmaculata* by the shorter guide and openings, and by having the openings more curved. The spermathecae of *P. nuecesensis* differs from those of *P. alboimmaculata* by having the anterior margin pointed and with the origin of the efferent ducts mesad, whereas *P. alboimmaculata* is more laterad.

Description.—Female: Poorly preserved, most colors faded, but in usable state for comparative purposes. Epigynum (Fig. 8). Spermathecae (Fig. 9). Cephalothorax orange-red (reddish-brown in ethanol); with sparse white hairs anteriorly, sparse, long, white hairs and few white spatulate hairs posteriorly. Abdomen orange-red (dark brown in ethanol); dorsum with many white, spatulate hairs, long white hairs anteriorly; venter orange-red (dark brown in ethanol) with few, white, spatulate hairs. Spinnerets reddish-brown. Sternum brown with white, spatulate hairs, margins with long, white hairs. All legs reddish-orange. Femur I with white spatulate hairs forming a circular band on distal end. Femora II-IV with dorso-lateral strips of white, spatulate hairs. Patella I with circular white, spatulate, hair bands on ends. Matatarsus I has a longitudinal stripe of white, spatulate hairs on the retrolateral surface. All other segments unmarked. Total length, 4.41; carapace length, 1.64; carapace width, 1.23; leg I length, 2.77; leg II length, 2.18; leg III length, 2.14; leg IV length, 3.12.

Male: Color and markings essentially as female, but brighter. Cephalothorax and abdomen with white, spatulate hairs on posterior portions, number greatly reduced. Dorsum femur I and IV with thin, black hairs. Palpi (Fig. 4 and 5). Measurements of three mature males; holotype in parenthesis, paratypes after holotype. total length, (3.35) 2.69-4.83; carapace length, (1.56) 1.48-1.92; carapace width, (1.38) 1.04-1.48; leg I length, (3.26) 2.72-4.16; leg II length, (2.19) 1.96-2.75; leg III length, (2.16) 1.94-2.65; leg IV length, (2.83) 2.40-3.64.

Range.—Known only from the type locality.

Habitat.—The four known specimens were taken as adults in early April and August by sweeping low vegetation; a female and one male from *Gaillardia pulchella* (Compositae), the other males on salt-grass.

ACKNOWLEDGMENTS

We are grateful to Dr. H. W. Levi, Museum of Comparative Zoology at Harvard University, for the loan of the holotype of *Poultonella alboimmaculata* and Dr. W. J. Gertsch, Portal, Arizona for critical review of the manuscript.

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OBSERVATIONS OF TWO NOCTURNAL ORBWEAVERS THAT BUILD SPECIALIZED WEBS: *SCOLODERUS CORDATUS* AND *WIXIA ECTYPA* (ARANEAE: ARANEIDAE)

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ABSTRACT

The nocturnal araneid *Scoloderus cordatus* Taczanowski was observed in Florida and found to spin the same remarkable "inverted ladder web" described by Eberhard (1975) for a South American species. Other aspects of the spider's natural history and the unique "asterisk web" of another nocturnal araneid, *Wixia ectypa* Walckenaer, are described for the first time.

INTRODUCTION

Historically in the study of spiders, behavioral observation has lagged behind taxonomic description. This is particularly true for those genera in the orb weaving family Araneidae which spin their webs at night fall and take them down at dawn. However, the number of behavioral studies of nocturnal orbweavers is increasing and recent studies in the tropics have turned up a number of genera which show striking deviations from the standard orb web design and construction process (Robinson and Robinson 1972, 1975, Clyne 1973, Eberhard 1975). This paper deals with two species whose natural history shows that equally exciting discoveries are possible in the United States.

Scoloderus cordatus (Taczanowski) and *Wixia ectypa* (Walckenaer) are small brown spiders, with an average adult female length of approximately 5mm, which rest during the day on a brown twig with their legs pressed to the side of the body such that they closely resemble a bud or a broken side branch of the twig (Figs. 1, 2). Their similar appearance and diurnal cryptic behavior belie their radically different web forms. *S. cordatus* spins a narrow vertical "inverted ladder web" up to 1.2m (4 ft.) long (Fig. 4), a web form first described by Eberhard (1975). *W. ectypa*, on the other hand, spins an "orb web" consisting solely of a hub and radii (Fig. 3) which is described for the first time here and which I propose to call an "asterisk web".

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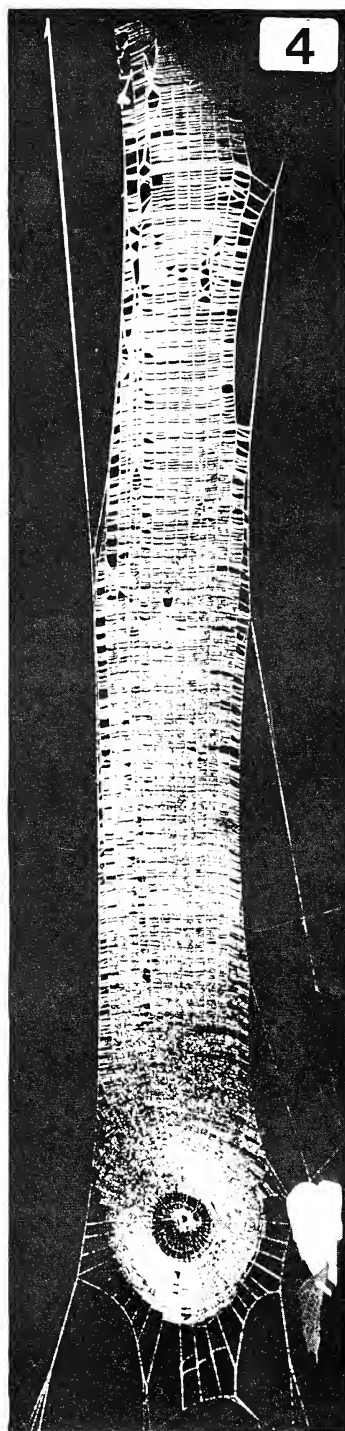
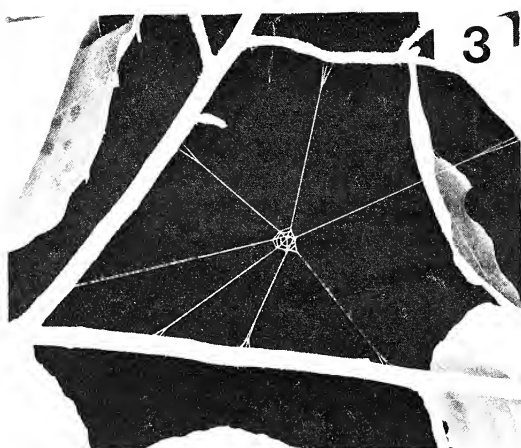
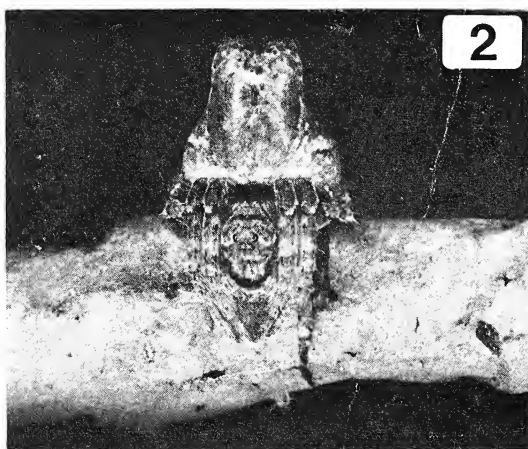


Fig. 1.—*Scoloderus cordatus* adult female (length 5 mm) in cryptic diurnal posture on dead twig.
 Fig. 2.—*Wixia ectypa* adult female (length 5 mm) in cryptic diurnal posture on a branch.
 Fig. 3.—The "asterisk web" made by *Wixia ectypa* (longest radius 6 cm).
 Fig. 4.—The 70 cm web of an adult female *Scoloderus cordatus*.

METHODS

I studied *S. cordatus* during June, July and August of 1975 at the Archbold Biological Station, Lake Placid, Highlands County, Florida. The species is widely distributed in Florida (Levi 1976). *W. ectypa*, which is found along the East Coast of the U.S. (Levi 1976), was studied on the grounds of The Spider Museum, Powhatan, Powhatan Co., Virginia, during the summer of 1977.

Both species were found by chance after surveying at night with a headlamp. The spiders were quite common in the respective study areas, *S. cordatus* in vegetation bordering mowed grass, *W. ectypa* in the outer branches (low and high) of trees. Some observations were made with caged spiders.

I observed *S. cordatus* by placing markers near webs early in the evening and visiting the spiders hourly throughout the night. *Wixia ectypa* was observed over shorter (approx. two hour) periods at different times each night.

Cornstarch was dusted onto the webs to make them visible in the photographs (Eberhard 1976). For the *W. ectypa* web it was necessary to spray the web with a fine mist of water first so that the cornstarch would stick. Since dusting alarmed the spiders and caused them to damage or take down their webs, spiders were removed from the hub and hence do not appear in the photographs. In order to photograph the spiders in their natural diurnal resting sites, I followed the spiders after they took down their webs at dawn.

Scoloderus cordatus

The Web.—The spiders spin for the first time as early as shortly after sunset and as late as 0100 hrs. The spiders appeared to spin earliest on those days when the afternoon rains were late and when the sky was clear overhead.

The method of construction is essentially the same as that in the South American *S. tuberculifer* O. P. Cambridge (Eberhard 1975). Features not seen in the typical orb include the position of the hub near the bottom of the web, long parallel radii in the upper part of the web, web construction starting with an inverted “Y,” and failure to remove the temporary spiral in the upper part of the web. Web length averaged 50 cm and width 7 cm (N=168) but webs up to 1.2 m long were seen. Larger webs took up to three hours to build. No webs deviated perceptibly from the vertical as gauged by a plumb bob.

The spiders take down and eat their webs usually one hour before dawn. Webs are destroyed by breaking the lower mooring threads and gathering up the web from the bottom.

Eberhard (1975) presents several hypotheses for the adaptive value of this unusual web form. I found evidence for one of these: increased moth capturing efficiency. A moth that flies into a normal orb is held only briefly because its scales come off and cover the viscous threads (Eisner *et al.* 1964). At first, a moth that flies into a *S. cordatus* web does not stick either. But unlike most orbs, the web is perfectly vertical, so the moth cannot fall out. Nor can it simply fly out since the web's fine mesh prevents the moth from fluttering effectively. The moth cannot control the direction of its struggles and frees itself from the original site of impact only to shift down into the viscous mesh below. If the moth originally flew into the upper part of the web it will descend through so many viscous threads that it will eventually lose enough scales that the viscous thread will adhere, at which point the moth descends no further. Over the summer I saw hundreds of

webs with the characteristic vertical trail of scales left as a result of this process. Moths form the bulk of the spider's prey at the station (68% by number, N=212) and form a larger part of *S. cordatus* diet than of the diet of three other nocturnal orbweavers that spun nearby: *Eriophora ravilla*, *Wagneriana tauricornis*, and *Eustala anastera* (Stowe, unpublished). By making a long, narrow web the spider has effectively maximized its moth capturing potential while avoiding the unmanageably large web area of a normal orb of the same length.

Reproductive Behavior.—Courtship begins when a wandering male finds a female's web and spins a horizontal line to the upper portion of one of the vertical frame threads. The male strums the line with legs I and II, attracting the female from the hub. As soon as the female touches the line, the male turns around so that his spinnerets face the female.

What happens next is difficult to interpret. It seems that when the male turns around, he both attaches the line to his spinnerets and breaks it near his mouth and thus spans the broken line with his body. The female apparently attempts to crawl onto the strand but, like a mountain climber who tries to climb a rope that only gives slack, ends up reeling silk from the male's spinnerets. Although all I could be certain of was the flailing of the female's legs, the behavior reported above fits the pattern observed in *Isoxya* Simon (Robinson pers. comm.).

When the female stops pulling, the male turns around and strums the line until she starts again. As the cycle is repeated the male draws closer until eventually he strokes her whereupon they mate in the position classified type I by Gerhardt (1911) (mating observed once, courtship over 20 times).

Males appear to survive most matings; of 212 prey items I found females eating over the summer only one was a male spider. After mating, males may sustain themselves by stealing small prey from the tops of females' webs (one observation).

One captive female made a flocculent white egg case containing approximately 50 eggs in the corner of its cage and a day later spun a normal ladder web. In nature females probably hide the egg case and produce more than one brood.

Wixia ectypa

The Web.—The spiders spin at dusk. The spinning process was extremely difficult to observe since it takes the spiders less than two minutes to make the web. I was able to observe parts of the procedure by labeling the diurnal resting positions of several spiders at dawn and walking from one position to another at nightfall until one spider was found spinning.

Although I never saw the first steps, I presume that the spider starts as many araneids do, with a "Y" consisting of three radii (Witt *et al.*, 1968). Construction of subsequent radii starts in typical araneid fashion; as the spider proceeds from the hub down an extant radius toward the branch, a line (running back to the hub) is pulled from its spinnerets. The spider, holding this line away from its body with one leg IV, walks a short distance down the branch. The spider then attaches the line to the branch and returns to the hub along it. Unlike the radii of any described orb webs, most of the asterisk web radii end in two or three attachment points (e.g. the 12 o'clock radius in Fig. 3). Somehow the multiple attachments are created in one motion as the spider turns to climb onto the radius. It appears that the spider does not roll up and replace the original thread as it returns to the hub as most orbweavers do since no puffs of rolled up thread were evident.

Instead it lays new thread over the original line: I was able to separate most radii into two strands by pulling apart the attachment threads. With a few turns the spider produces a simple mesh hub. Although a few more radii may be added, hub construction usually marks the end of the web spinning process. Checking the webs at different times during the night confirmed that nothing is ever added to this remarkably simple structure which contains no sticky lines. The typical web has eight radii, is more nearly horizontal than vertical and fills in the fork of a branch (over 100 observed). Webs are usually absent during the day but I never observed the dismantling process.

The spider preys on pedestrian arthropods and the web serves as a trip line snare. The channeling effect of the narrow branches on arthropod traffic enables the spider to exploit a large number of prey (larger than the simplicity of the web would suggest) while investing a minimum of time and silk in web construction.

I observed capture sequences by first creating vaseline barriers around the web. These confined introduced arthropods to branches with radius endpoints for enough time to allow the spider to recover from the disturbance created by introducing the arthropod (7 spiders used, 16 capture sequences observed). The sequence begins with the spider rushing down a radius that the prey has just brushed against (presumably the multiple attachments increase the chances of contact). If the prey item is not in the immediate vicinity of the radius endpoint the spider runs back and forth on the branch until contact is made. The spider is now in an unusual position for an orbweaver as it must tackle a prey item that grasps a solid substrate. Usually the spider first ties down the prey by rapidly circling the branch and the prey while laying down swathing silk. This prevents the prey from escaping and facilitates subsequent biting. When the venom takes effect, the prey is freed from the branch by biting the restraining threads and after more wrapping the prey is eaten at the capture site or at the hub.

This capture technique presumably requires closer contact and involves more risk to the spider than that employed by most orbweavers. Spiders did not attack all the kinds of arthropods introduced (e.g. predatory Hemiptera) and perhaps they can differentiate the vibrations produced by different taxa. The 11 identifiable prey items taken from spiders found eating consisted of eight weevils (*Cyrtopistomus castaneus* Roelofs), one mite, one opilionid and one alate ant.

DISCUSSION

Presumably the ancestors of these two spiders spun normal orb webs. Drastic modification of this type of web has enabled the two genera to exploit prey not effectively exploited by most orbweavers: moths in the case of *Scoloderus* Simon and pedestrian arthropods in the case of *Wixia* O. P. Cambridge. It is relatively easy to imagine how the ladder web might have evolved. However, it is difficult to imagine intermediates between the normal orb and the asterisk web and it would be of interest to determine what kind of webs are made by genera related to *Wixia*.

Working at night poses many difficulties but I hope my observations may encourage others to look at the large percentage of spiders that are strictly nocturnal. Even for the sole purpose of collection, searching at night with a headlamp is, in my experience, more effective than beating and sweeping vegetation during the day for many species.

ACKNOWLEDGEMENTS

I wish to thank H. W. Levi, I. Goldfarb and M. Berenbaum for their criticism of the text, the Archbold Station staff, and A. Moreton for their assistance and support, and R. Hoebeke and H. W. Levi for identifying specimens.

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THE USE OF FEMORAL SPINATION AS A KEY TO INSTAR DETERMINATION IN THE GREEN LYNX SPIDER, *PEUCETIA VIRIDANS* (HENTZ) (ARANEIDA:OXYOPIDAE)^{1,2}

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ABSTRACT

An alternative method of instar determination was sought by documenting femoral spination of successive instars of the Green Lynx Spider, *Peucetia viridans* (Hentz). Instars two through five were accurately determined by femoral spine number. Instars six and seven showed subtle, yet detectable differences in femoral spine relationships. Although instars seven and higher exhibit no easily perceivable differences in femoral spine relationships this spider is either mature or in penultimate stages in those instars. No sex differences in femoral spination were observed.

INTRODUCTION

Immature stages account for much of the predation attributed to spiders and it is often important to be able to determine the instar of immatures quickly and accurately in the field. Carapace widths have been used for instar determinations for many species. Dondale (1961) reported that strongly sclerotized body parts, such as the carapace and legs, were generally less variable than other linear measurements of body parts used to document spider growth. He noted that much of the variation affecting significance of measurements was due to difficulty in orienting the body of the spider in a consistent manner.

Although carapace widths are among the least variable body parts with respect to linear measurements, several authors (Eason and Whitcomb 1965, Whitcomb *et al.* 1966, Peck and Whitcomb 1970) have demonstrated that these overlap from instar to instar. As a consequence instar determinations are frequently in error. Growth varies depending on factors such as diet, humidity, temperature and photoperiod. Such factors in turn account for variations in carapace widths and other highly sclerotized body parts. Turnbull (1962) reported that the influence of the rate of food consumption on the rate of development declines with each consecutive instar. This may account for less variation in carapace width as the spider gets older. Turnbull also found that when feeding rates fell below the amount required for survival the spider will continue to mature. If the spider

¹ Florida Agricultural Experiment Station Journal Series No. 1017

² Part of a thesis submitted by the author in partial fulfillment of the requirements for the M.S. degree at the University of Florida.

survives long enough to molt but lacks the extra energy required for molting it will die. A spider that has the energy to molt can complete the molt but emerges from the exuvium in the subsequent stage smaller than it was in the previous stage; a third instar spiderling may become a fourth instar but be the size of a second instar spiderling. If the carapace width was used as the instar determinant the spider would be erroneously described as a second instead of a fourth instar.

Chemicals used for preservation can further complicate linear measurement instar determination by causing shrinkage of body parts.

This investigation was conducted to determine if accurate field identification of instars could be made from examination of the femoral spination of a spider's legs. Because of its availability, size, abundance, and relatively few femoral spines that can all be observed from the dorsal aspect; the Green Lynx Spider, *Peucetia viridans* (Hentz) was chosen as the subject of this investigation.

LITERATURE REVIEW

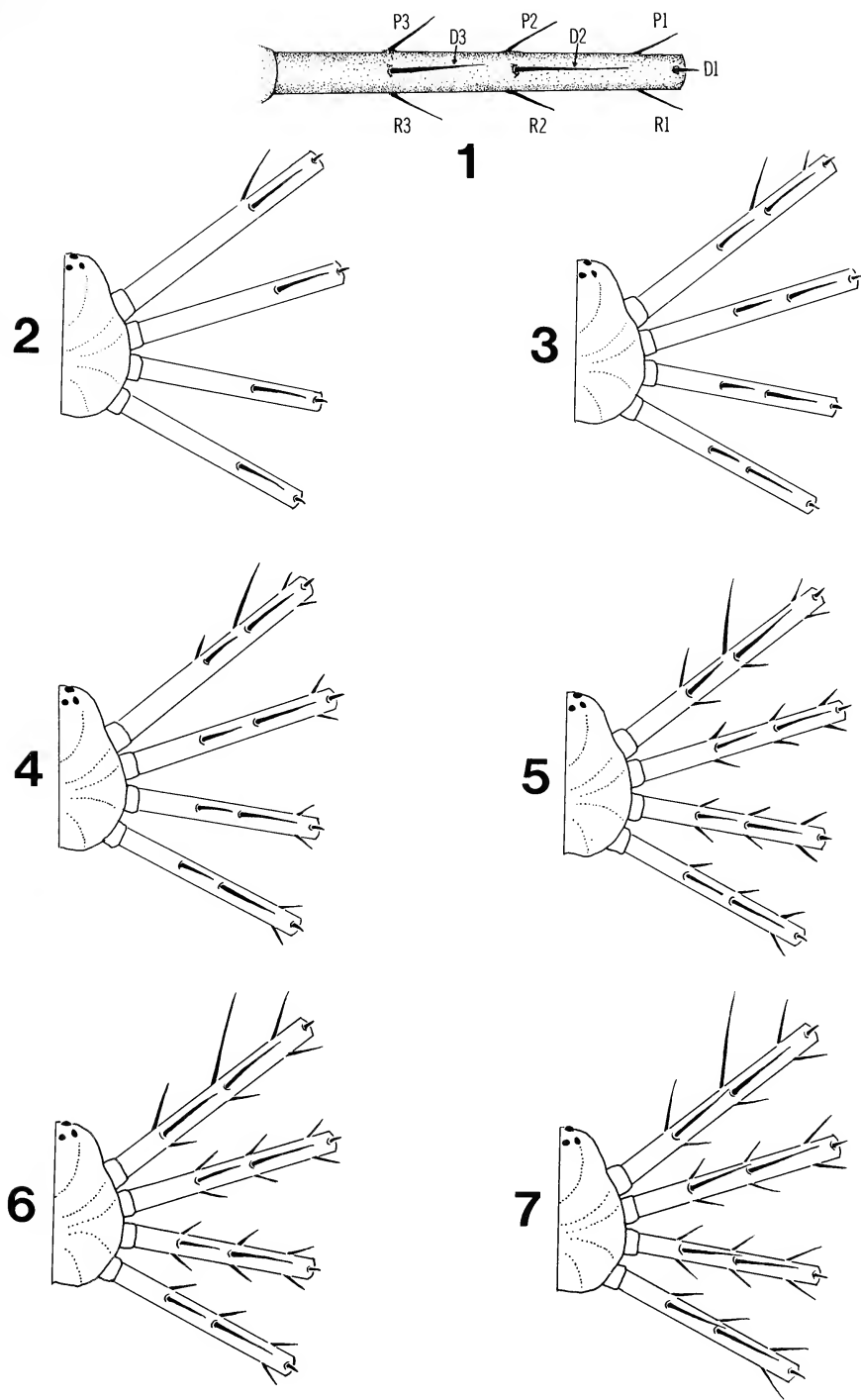
The usefulness of chaetotaxy in taxonomy has been noted by several authors. The term "spine" used in this report as in most arachnological literature, defines the largest of the three generally accepted classes of arachnid setae: spines, bristles and trichobothria. All three classes are setae in the entomological sense since they extend from an alveolar socket. Spines are large heavy setae; bristles are finer and shorter than spines; and the finest setae are termed trichobothria. Kaston (1948) stated that the presence, arrangement, and location of trichobothria on the different leg segments was fairly constant for various higher taxa. Lehtinen (1967) considered the setae of spiders to be of phylogenetic significance at the family and generic levels. According to Stahnke (1973) the trichobothrial clusters of Vaejovidae and other scorpion families seem to be transmitted genetically and that certain clusters are relatively constant within those families. Chamberlin and Ivie (1940) used leg spination in their key to the species of the genus *Cicurina* (Agelenidae). They formulated a "typical leg" with all the spines that might occur on any leg of any species of *Cicurina*. Spines were assigned a code number and in the descriptions "absent" spines were noted for each particular species.

Carmichael (1973) found the spines of the second tibia of *Araneus trifolium* (Hentz) and *Araneus marmoreus* Clerck were consistent enough to be distinct for those two species. Reiskind (1969) noted that the ventral spination of the tibia of leg I in the sub-family Castianeirinae was fairly constant and easily observable and was useful in distinguishing between species and species groups.

Emerit (1964) reported that the trichobothria of *Gasteracantha veriscolor* Walckenaer followed a progressive developmental pattern and it was possible to identify the different instars of *G. veriscolor* using the trichobothrial patterns.

Peck and Whitcomb (1970) using a system similar to that of Chamberlin and Ivie, found the leg spination of *Chiracanthium inclusum* (Hentz) to be different in successive instars. The carapace width measurements of *C. inclusum* were unreliable for accurate instar determination. Although the developmental chaetotaxy showed no constant condition for any instar except the first and second, the combination of carapace width and leg spination was found to be of value as an indicator of instar for *C. inclusum*.

Beatty (1970), studying the genus *Ariadna* Audouin (Dysderidae) found the femoral spines of the adult females and juveniles to be constant. The dorsal femoral spination of the adult males was highly variable both inter- and intraspecifically. Of the several hundred adult specimens examined, none had total symmetrical spination and spine



Figs. 1-7.—Femoral spination of *Peuceetia viridans* (Hentz) (P, prolateral; R, retrolateral; D, dorsal): 1, adult; 2, second instar; 3, third instar; 4, fourth instar; 5, fifth instar; 6, sixth instar; 7, seventh instar.

patterns were individually unique. Beatty also found that in *Ariadna bicolor* (Hentz) spination changes could be induced by transient or local physiological changes, including injury.

METHODS AND MATERIALS

Adult *P. viridans* females were collected from several different locations in northern Florida and brought to the laboratory. After producing an egg sac, the females were allowed to remain with their egg sacs until the young emerged. After emergence the spiderlings were placed in separate rearing containers. The young were considered to be second instar spiderlings at emergence since they had molted from the deutovum while still in the egg sac (Whitcomb *et al.* 1966) and had functional eyes, digestive system and spines upon emergence from the egg sac.

The exuvia were removed from the rearing containers after each molt thus insuring against mistakes in instar identification of laboratory specimens.

Spiderlings representing the different instars were removed from the rearing containers and femoral spination examined as they became available. Samples (spiderlings) of the different instars were taken from as many of the egg sacs as possible to study the variation from egg sac to egg sac as well as the variation within a single egg sac.

Few spines occur on the femora of *P. viridans* (legs I-III have 9 spines and leg IV has 7 spines on the adult femora). Although possible to predict the relative positions of the femoral spines on immatures from the spination of the adult *P. viridans* (Fig. 1), the

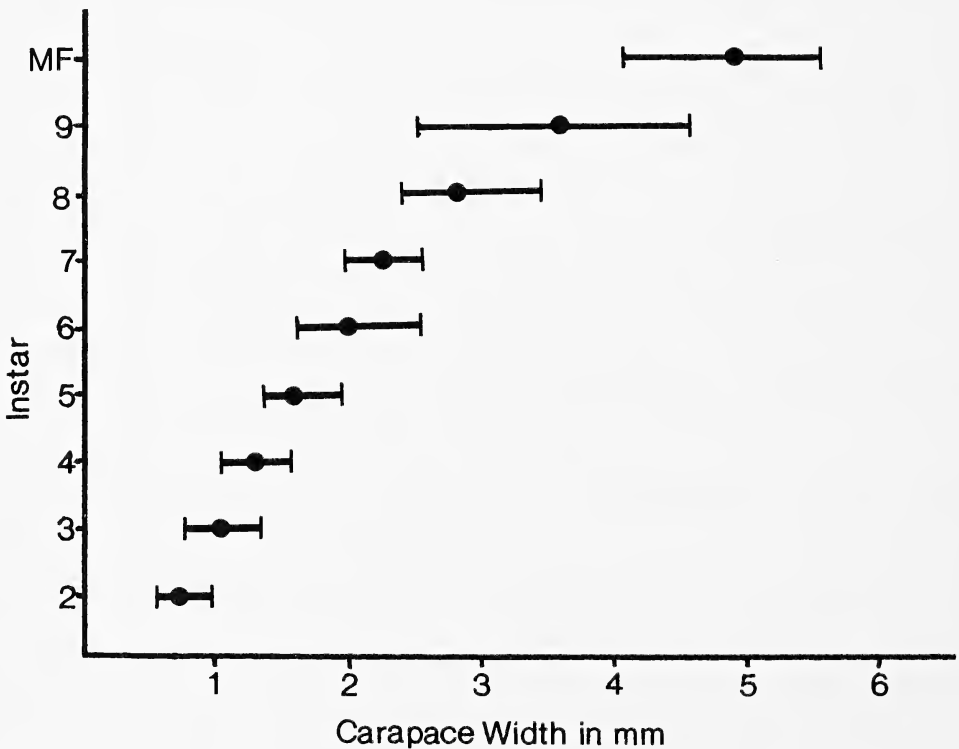


Fig. 8.—Carapace width measurements of successive instars of laboratory reared *Peucea viridans* (Hentz), and mature females caught in the field (MF).

succession and progressive alterations in size relationships of the femoral spines of immatures could not be predicted from examination of adults. If spines were broken off, the sockets remained so the number and position of those spines could be documented.

RESULTS

The succession of spine number for the dorsal, prolateral and retrolateral aspects of the femora of legs I-IV is shown in Table 1.

The progressive intra-instar femoral spine relationships for legs I-IV, using the D1 spine as a size standard are shown in Table 2. Femoral spination for legs I-IV of instars two through seven is shown in Figures 2-7. Since these spiders are bilaterally symmetric only the right half is illustrated.

The carapace width measurements taken during this investigation are indicated in Figure 8.

Table 1.—Succession of femoral spination on the legs of *Peucetia viridans* Hentz, indicated as follows—prolateral:dorsal:retrolateral.

Instar	N	Leg I	Legs II-III	Leg IV
2	78	1:2:0	0:2:0	0:2:0
3	54	2:3:0	0:3:0	0:3:0
4	42	3:3:1	1:3:1	1:3:1
5-9	85	3:3:3	3:3:3	3:3:1

Table 2.—Progressive intra-instar femoral spine relationships for legs I-IV in *Peucetia viridans* (Hentz). (Spines are numbered from distal to proximal: L, leg; I, instar; P, prolateral; D, dorsal; R, retrolateral). The number of plus (+) marks denotes the spine size relationships within an instar. When plus marks appear in parenthesis (++) , that spine or spines are usually absent but have appeared in a few cases, the number of which also appear in parenthesis.

L	I	N	P1	P2	P3	D1	D2	D3	R1	R2	R3
I	2	78	—	++	—	+	++	—	—	—	—
	3	54	++	+++	—	+	+++	++	—	—	—
	4	42	++	++++	++	+	++++	+++	—	—	—
	5	21	++	++++	++	+	++++	+++	++	++	++
	6	22	+++++	+++++++	+++++	+	+++++	+++++	+++	++	++
	7	23	+++++	+++++++	+++++	+	+++++	+++++	+++	++	++
	8	12	+++++	+++++++	+++++	+	+++++	+++++	+++	++	++
	9	7	+++++	+++++++	+++++	+	+++++	+++++	+++	++	++
	9	7	+++++	+++++++	+++++	+	+++++	+++++	+++	++	++
II-III	2	78	—	—	—	+	++	—	—	—	—
	3	54	—	—	—	+	+++	++	—	—	—
	4	42	++	—	—	+	++++	+++	++	—	—
	5	21	++	++	++	+	++++	+++	++	++	++
	6	22	+++	++	++	+	+++++	+++++	+++	++	++
	7	23	+++	++	++	+	+++++	+++++	+++	++	++
	8	12	+++	++	++	+	+++++	+++++	+++	++	++
	9	7	+++	++	++	+	+++++	+++++	+++	++	++
	9	7	+++	++	++	+	+++++	+++++	+++	++	++
IV	2	78	—	—	—	+	++	—	—	—	—
	3	54	—	—	—	+	+++	++	—	—	—
	4	42	++	—	—	+	++++	+++	++	—	—
	5	21	++	++	++	+	++++	+++	++	—	—
	6	22	+++	++	++	+	+++++	+++++	+++	(++)(1)	—
	7	23	+++	++	++	+	+++++	+++++	+++	—	—
	8	12	+++	++	++	+	+++++	+++++	+++	—	—
	9	7	+++	++	++	+	+++++	+++++	+++	(++)(2)	—
	9	7	+++	++	++	+	+++++	+++++	+++	(++)(2)	—

Second Instar—The femoral spines of *P. viridans* are conspicuous as soon as the spiderlings emerge from the egg sac. None of the spiderlings examined showed any deviation from the pattern and spine number indicated in Fig. 2. Leg I has the P2, D1 and D2 spines and legs II-IV have only the D1 and D2.

Third Instar—The spiderlings acquired two more spines; P1 and D3 on leg I and one more spine, D3 on legs II-IV. The spiderlings have their full complement of dorsal spines as indicated in Fig. 3.

Fourth Instar—All the prolateral spines of leg I are present with the addition of the P3 spine. The P1 and R1 spines of legs II-IV are present. Only a single specimen showed any variance from the pattern and number shown in Fig. 4. That specimen had an R2 spine on leg IV of the left side with no spine or alveolar socket at the corresponding site of the same leg on the right side. This is in contrast to other variations observed in this investigation since individual variations were generally bilaterally symmetric.

Fifth Instar—The spiderlings have the full complement of nine femoral spines on legs I-III and seven femoral spines on leg IV as indicated in Fig. 5. Leg I has the R2 and R3 spines; legs II and III have the P2, P3, R2 and R3 spines; and leg IV has the P2 and P3 spines. Instars two through five can be distinguished by spine number alone. The P1 spine is longer than the P3 spine on leg I.

As evident from examination of Table 2 the subsequent sixth and seventh instars show only slight, yet measureable changes in femoral spine relationships.

Sixth Instar—Following the molt to the sixth instar the P1 and P3 spines of leg I are the same length. Legs II-IV of the fifth instar exhibit the following relationship with respect to spine length: $P1 = R1 > P2 = P3, R2, \text{ and } R3$. In the sixth instar all prolateral and retrolateral spines of legs II-IV are the same length.

Seventh Instar—Up to and including the sixth instar the D2 spine is longer than the D3 on legs I-IV; in the seventh instar they are of equal length. The intra-instar femoral spine relationships remain unchanged from instars seven through nine which is of little practical consequence since by these stages of the life history the spiders are reaching sexual maturity. The earliest penultimate individual observed was a seventh instar male and by the ninth instar all specimens were sexually mature. No sex differences in femoral spination were observed.

The only variations evident from this investigation were on leg IV of the sixth instar (1 case) and the ninth instar (2 cases). These variations were cases of neotrichy where the normally absent R2 spines of leg IV were present.

A double-blind test of twenty-five field and twenty laboratory specimens was performed resulting in the correct instar determination of all spiderlings examined using only femoral spination as the key.

CONCLUSION

As Carmichael (1973) stated concerning the leg spines of *A. trifolium* (Hentz) and *A. marmoreus* Clerck, three important factors are evident: (1) there is a clear difference between spines and hairs, (2) the presence of a socket will indicate location of a lost spine, and (3) it is possible to recognize each spine. Those factors apply especially well to the femoral spination of *P. viridans*. I consider the femoral spination of the Green Lynx spider to be the best indicator of instar for this species.

Spine number alone can be used for determination of instars two through five. Instars six and seven exhibit subtle yet detectable differences in intra-instar femoral spine relationships. Carapace width measurements may serve as a secondary aid to accurate instar determination. Although instars seven and higher exhibit no easily perceivable differences in femoral spine relationships *P. viridans* is either mature or in penultimate stages in those instars. No sex differences in femoral spination were observed.

No generalizations should be drawn from this report. The use of femoral or entire leg spination as an instar determinant must be investigated on a species to species basis; however, I firmly believe that examination of leg segment or entire leg spination is a likely character for accurate instar determination in other spider species.

ACKNOWLEDGEMENTS

I thank Dr. W. H. Whitcomb, Dr. J. Lloyd and Dr. J. Reiskind for their continual interest, aid and invaluable criticism of this investigation and manuscript. I also thank Dr. R. Sailer and Dr. S. Poe for reviewing the manuscript. I especially thank my wife, Carol, for the many hours of aid given to this investigation both in the field and laboratory.

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RESEARCH NOTE

A SECOND SPECIES OF THE GENUS *MEXICHTHONIUS* (PSEUDOSCORPIONIDA, CHTHONIIDAE)

The genus *Mexichthonius* was based on *M. unicus* Muchmore (*J. Arachnol.* 3:1-4, 1975) described from a single female taken at Ich-Ek (near Hopelchen), Campeche, México, in 1973. Despite continued (albeit sporadic) collecting in southeastern México by several people, only one other specimen pertaining to this remarkable genus has been found. That, also a female, proves to represent a second species.

Mexichthonius pacal, new species Figures 1-3

Material.—Holotype female (WM 3987.02001) collected by Tullgren funnel extraction from rotted wood from forest near Chacomax River, Palenque, Chiapas, México, 24 March 1975 (C.H. Alteri). The type is in the Florida State Collection of Arthropods, Gainesville.

Diagnosis.—Much smaller than *M. unicus*, the only other species known in the genus; with carapace 0.30 mm long and palpal femur 0.26 mm long.

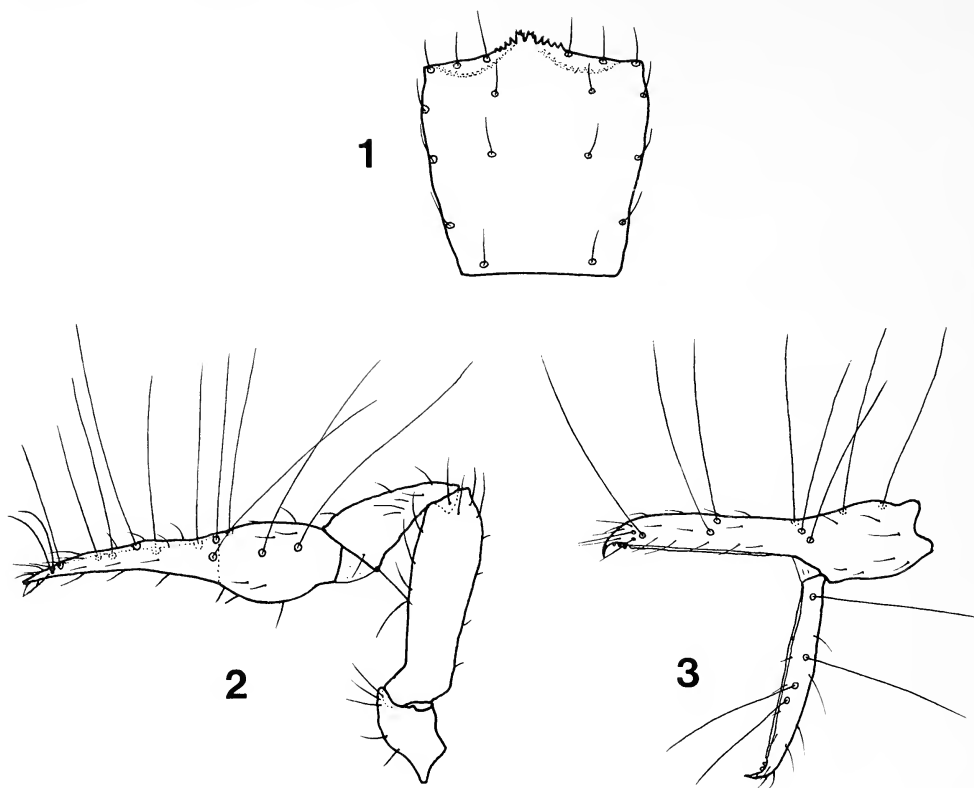
Description.—Female similar to *M. unicus* in general features. All parts nearly colorless. Carapace 1.1 times as long as broad, narrowed posteriorly (Fig. 1); anterior margin with large, serrate epistome and flanking denticles; no eyes; chaetotaxy 6-4-4-2-2=18. Coxal area typical; chaetotaxy 2-2-1:mmm-2-1:2-4-CS:2-5:2-5; lateral seta on apex of palpal coxa short and strongly curved medially; coxal spines consist of one large, complex lateral and five small spines medially; no intercoxal tubercle. Abdomen typical; tergal chaetotaxy 4:4:6:6:6:6:(lost); sternal chaetotaxy 5:(2)6(2):(1)6(2):9:(lost).

Chelicera large, 0.85 as long as carapace; hand with five setae; flagellum of eight pinnate setae; spinneret a distinct knob.

Palp slightly more robust than that of *M. unicus*, but with relatively longer chelal fingers (Figs. 2 and 3); trochanter 1.85, femur 3.25, tibia 2.1 and chela 3.8 times as long as broad; hand 1.4 times as long as deep; movable finger 1.93 times as long as hand. Trichobothria essentially as in *M. unicus*, notably with *isb* and *ib* in tandem on dorsum of hand. Fixed finger with three small denticles just behind terminal tooth, followed by a low, irregular lamella, and with a small, internal accessory denticle distally; movable finger similarly with five distal denticles and a lamella. Movable finger with a small sensillum on external surface near dental margin just proximal to level of trichobothrium *sb*.

Legs typical, stout; leg IV with entire femur 2.0 and tibia 3.7 times as long as deep.

Measurements (mm): Body length about 1.0. Carapace length 0.30. Chelicera 0.25 by 0.14. Palpal trochanter 0.13 by 0.07; femur 0.26 by 0.08; tibia 0.17 by 0.08; chela 0.38 by 0.10; hand 0.14 by 0.10; movable finger 0.27 long. Leg IV: entire femur 0.25 by 0.125; tibia 0.185 by 0.05.



Figs. 1-3.—*Mexichthonius pacal*, new species: 1, carapace; 2, dorsal view of right palp; 3, lateral view of left chela.

Male.—Unknown.

Etymology.—The species is called *pacal* for the Mayan priest-king of that name.

Remarks.—The type locality of *Mexichthonius pacal* at Palenque, Chiapas, is over 200 miles southwest of Ich-Ek, Campeche, type locality of *M. unicus*. It seems likely that the genus is distributed through southern México and Central America, but further information must await extensive collection of the soil microfauna of the area.

Other pseudoscorpions collected along with *M. pacal* include representatives of the genera *Aphrastochthonius*, *Tyrannochthonius*, *Pseudochthonius*, and *Albiorix*.

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RESEARCH NOTE

ON *JOSA ALBA* MELLO-LEITÃO (ARANEAE, ANYPHAENIDAE)

Mello-Leitão (1945) described a male anyphaenid from Misiones, Argentina, and placed it in the then monotypic genus *Josa*, established by Keyserling (1891) for *Anyphaena pilosa* Keyserling (1879), a species known only from Colombia. Keyserling's original description of *A. pilosa* indicates the presence of a retrolateral apophysis on the male palpal femur of the same form found in the type species of the genus *Haptisus* Simon (1897), *Anyphaena citrina* L. Koch (1866, Fig. 134). The peculiar femoral apophysis is probably a synapomorphic character and *Haptisus* should probably be considered a junior synonym of *Josa* (J. A. Kochalka, *in litt.*). The male described by Mello-Leitão, however, lacks a femoral apophysis, and his illustration of the male palp strongly suggests that of a *Wulfila*. Through the courtesy of Dra. Olga M. Blanco of the Museo de La Plata, I have recently been able to examine the type of *Josa alba* and can confirm that it does indeed have the pale coloration and extremely elongated legs characteristic of *Wulfila*. As the name *Wulfila alba* is preoccupied by a North American species (see Platnick 1974:245), a replacement name is offered with the redescription below.

I am indebted to Mr. John A. Kochalka of the University of Vermont for much informative discussion on South American anyphaenids and to Dr. Mohammad U. Shadab of the American Museum of Natural History for providing the illustrations. The format of the description follows that of Platnick (1974); all measurements are in millimeters.

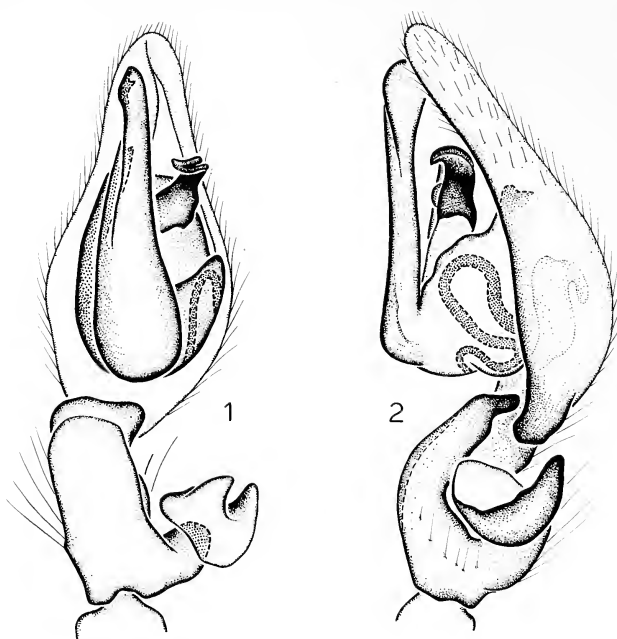
Wulfila argentina, new name

Figures 1-2

Josa alba Mello-Leitão, 1945:264, Fig. 50 (male holotype from Puerto Victoria, Misiones, Argentina, in Museo de La Plata, examined). Roewer, 1954:541. Preoccupied by *Wulfila alba* (Hentz).

Diagnosis.—*Wulfila argentina* seems closest to *W. tantilla* Chickering (known from Texas south to Panama); in both species the retrolateral tibial apophysis has a broad and rounded bifurcated tip (cf. Platnick 1974, Figs. 85, 86). The former species can be easily distinguished by its much larger median apophysis (Figs. 1, 2).

Male.—Entire body, except for orange palpal tibia and tarsus, pale yellow. Total length 3.13. Carapace 1.55 long, 1.12 wide; cephalic width 0.58, clypeal height 0.07. Eyes: diameters, AME 0.04, ALE 0.09, PME 0.07, PLE 0.09; anterior eye row 0.35 long, straight; posterior row 0.50 long, procurved; MOQ length 0.24, front width 0.10, back width 0.28; interdistances, AME-AME 0.03, AME-ALE 0.04, PME-PME 0.13, PME-PLE 0.08, ALE-PLE 0.05. Sternum 0.92 long, 0.67 wide. Chelicerae 0.54 long, with 5 promarginal teeth and 7 retromarginal denticles. Abdomen 1.87 long, 1.22 wide. Epigastric furrow 0.74 from tracheal spiracle, spiracle 0.70 from base of spinnerets. Tibial lengths and indices: I missing; II 1.73, 7; III 0.96, 13; IV 2.02, 7. Ventral spination: tibiae I missing, II 2-2-0, III 2-1-0, IV 2-2-0; metatarsi I missing, II-IV 2-2-0. Coxae I with proximal, coxae II with proximal and distal spurs on venter. Palpus as in Figs. 1, 2.



Figs. 1-2.—*Wulfila argentina*: 1, palp, ventral view; 2, palp, retrolateral view.

Female.—Unknown.

Distribution.—Known only from northern Argentina.

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RESEARCH NOTE

THE IDENTITY OF *TITYUS MACRURUS* KOCH (ARACHNIDA, SCORPIONIDA, BUTHIDAE)

The scorpion *Tityus macrurus* Koch, 1845, was described on the basis of one male and one female from México. At the time this species was described the genus *Tityus* Koch was poorly characterized, and Koch assigned numerous species to it. Since then, the genus *Tityus* has been restricted to species found only in South America and southern Central America, and *T. macrurus* has been assigned to the genus *Centruroides* Marx, found mostly in North America, Central America, and the Caribbean islands. The position of the species within this genus, however, has not been clear. While Thorell (1876) indicated that *T. macrurus* is a junior synonym of *Centrurus biaculeatus* (Lucas) [= *Centruroides gracilis* (Latreille)] and Kraepelin (1899) listed the species as a synonym of *C. gracilis*, Pocock (1902), Hoffmann (1932), Moreno (1939), and Mello-Leitão (1945) referred *T. macrurus* to the synonymy of *Centruroides margaritatus* (Gervais). Both *C. gracilis* and *C. margaritatus* occur in México, and since the placement of *T. macrurus* within the genus *Centruroides* is uncertain, we examined the male type of *T. macrurus* to determine its identity.

The type of *Tityus macrurus* is definitely a species of the genus *Centruroides* and is very closely related to the species occurring in coastal Veracruz described and identified by Hoffmann (1932) as *C. gracilis*. However, as pointed out by one of us (Wagner, 1977), the name *Centruroides gracilis* is currently applied to a poorly understood complex of species and subspecies from a wide geographic area (Florida and Texas in the USA, México, Central America, the Caribbean Islands, and northern South America to Ecuador). The examination of the type specimens of all species (12) and subspecies (4) referred to the synonymy of *C. gracilis*, as well as those of closely related taxa of doubtful validity, is an essential step in the clarification of this taxonomic problem. Therefore, since the true identity of *C. gracilis* remains to be determined, we only tentatively assign *T. macrurus* as a junior subjective synonym of it. Below we provide a brief description of the type specimen of *T. macrurus*, and refer the reader to Hoffmann's excellent description if more detail is desired.

Descriptive notes.—Subadult male type, pinned and poorly preserved, in Zoologisches Museum of Humboldt-Universität zu Berlin. Agrees closely with Hoffmann's (1932) description of *C. gracilis* from the coastal region of the state of Veracruz, México (based on published description, and examination of specimens from that region). Postabdomen 7.1 times longer than carapace; pedipalp chela reddish brown, lighter than femur and tibia; sternite VII infuscate; pectinal tooth count 29-30; pedipalp chela fixed finger with nine rows of granules.

Measurements (in mm): Total length 74.5; carapace length 7.0, anterior width 3.9, posterior width 6.8; mesosoma length 18.4; metasoma length 49.7, segment I 6.5 (length) by 3.1 (width), II 7.7 by 3.2, III 8.6 by 3.0, IV 9.3 by 2.9, V 9.9 by 3.0, telson length 7.1, vesicle 5.0 by 2.5 by 2.3 (depth), aculeus length 2.7; pedipalp length 27.9, femur 7.1

We thank Dr. M. Moritz (Humboldt-Universität, Berlin) for the loan of the male type of *Tityus macrurus*. The junior author thanks the Graduate School, Texas Tech University, for support in the form of a Summer Fellowship.

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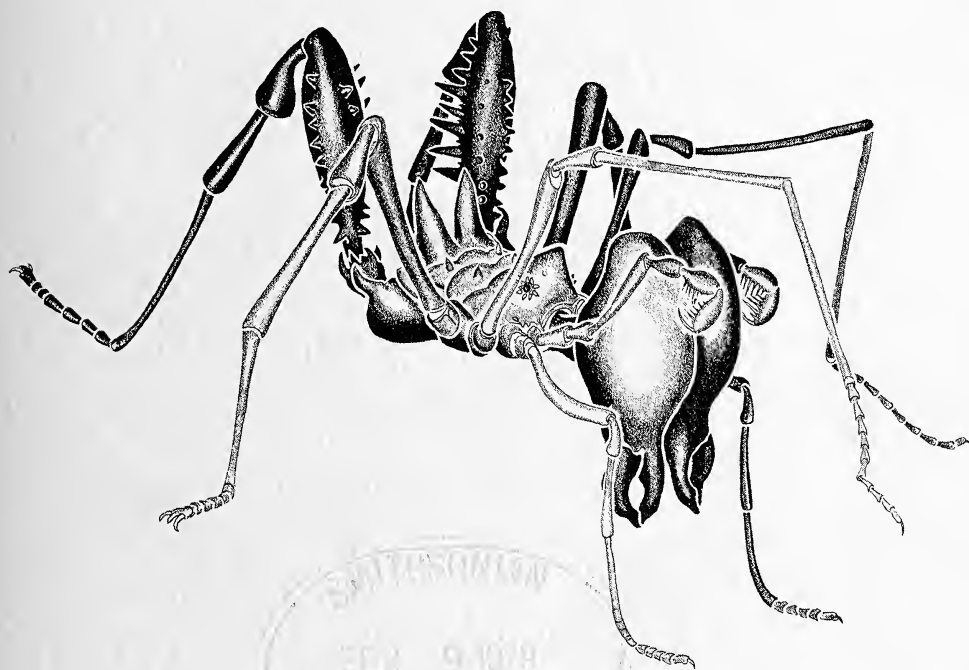
Printed by The Texas Tech Press, Lubbock, Texas

Posted at Warrensburg, Missouri, U. S. A., November 1978

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THE ORDER SCHIZOMIDA (ARACHNIDA) IN THE NEW WORLD. I. PROTOSCHIZOMIDAE AND *DUMITRESCOAE* GROUP (SCHIZOMIDAE: *SCHIZOMUS*)¹

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ABSTRACT

This is the first of a series of papers reviewing the systematics of the arachnid order Schizomida in the New World. The four species of the family Protoschizomidae are redescribed. Seven species groups of *Schizomus* (family Schizomidae) are recognized in the New World. The 13 species of the *dumitrescoae* group are described in this part. These are *Schizomus decui* Dumitresco, *S. dumitrescoae* n. sp., *S. cousinensis* n. sp., *S. primibiconourus* n. sp., *S. longipalpus* n. sp., *S. brevipatellatus* n. sp., *S. gladiger* Dumitresco, *S. monensis* n. sp., *S. desecheo* n. sp., *S. biconourus* n. sp., *S. insignis* Hansen, *S. peckorum* n. sp., and *S. viridis* n. sp.

INTRODUCTION

The order Schizomida includes 101 species divided very disproportionately between two families. The family Protoschizomidae includes two genera, each with only two species, and is known only from México. The family Schizomidae contains two subfamilies, the Megaschizominae and the Schizominae. The Megaschizominae includes one genus and two species and is known only from South Africa and Mozambique. The Schizominae includes the poorly known genus *Trithyreus*, containing only its type-species, *T. grassii* (Thorell), from Burma, and the world-wide genus *Schizomus* with 94 species. Rowland (1972) has discussed at some length the nomenclatural and systematic

¹Supported in part by The Museum, Texas Tech University, and by a Society of Sigma Xi Grant-in-Aid of Research to the senior author.

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history of the order. In that report he placed all African species of *Schizomus* in the genus *Trithyreus* and used a split or entire metapeltidium to separate the two genera. This character, however, is highly variable and appears to be of no phylogenetic significance. For the present we are considering all New World species to belong to the genus *Schizomus*. *Trithyreus*, however, has priority, and should a study of topotypes of *T. grassii* reveal that it is congeneric with other schizomids, the New World species must all be placed in *Trithyreus*.

No general review of the Schizomida has been published since that of Hansen and Sörensen (1905), and the only regional study is that of Lawrence (1969) for the Ethiopian Region. The cavernicole fauna of México, Guatemala, and Belize was reviewed by Rowland and Reddell (1977). The present systematic review of the New World Schizomida is based on a dissertation prepared by the senior author at Texas Tech University, Lubbock, Texas (Rowland, 1975a). This paper is the first of a series of reports and includes redescriptions of the four species of the family Protoschizomidae and a systematic study of one species group in the family Schizomidae. A general discussion of the zoogeography and phylogeny of the New World fauna will follow completion of the systematic study.

A total of 54 species of Schizomida are known from the New World. Of these, nine are from South America, one from Panama, two from Guatemala, 24 from México, two from Martinique, seven from Cuba, and eight from the United States. In addition, *Schizomus portoricensis* (Chamberlin) is known from Florida (U.S.A.), the Antilles, Bermuda, México, Guatemala, Costa Rica, Ecuador, the Galapagos Islands, and England (introduced). The present report adds 10 species to the New World fauna. The following is a chronological list of the described species of New World Schizomida:

Family Protoschizomidae:

- Agatoschizomus lucifer* Rowland, 1971a - San Luis Potosí, México
- A. huitzmolotitlensis* Rowland, 1975b - San Luis Potosí, México
- Protoschizomus pachypalpus* (Rowland, 1973a) - Tamaulipas, México
- P. occidentalis* Rowland, 1975b - Colima, México

Family Schizomidae:

- Schizomus pentapeltis* (Cook, 1899) - California, U.S.A.
- S. dispar* Hansen, in Hansen and Sörensen, 1905 - Martinique
- S. flavescens* Hansen, in Hansen and Sörensen, 1905 - Venezuela
- S. insignis* Hansen, in Hansen and Sörensen, 1905 - Martinique
- S. simonis* Hansen, in Hansen and Sörensen, 1905 - Venezuela
- S. portoricensis* (Chamberlin, 1922) - New World tropics
- S. guatemalensis* Chamberlin, 1922 - Guatemala
- S. antilus* Hilton, 1933 - Cuba (may be a synonym of *S. portoricensis*)
- S. wessoni* (Chamberlin, 1939) - Arizona, U.S.A. — NEW COMBINATION
- S. davisii* Gertsch, 1940 - Tamaulipas, México
- S. mulaiki* Gertsch, 1940 - Texas, U.S.A.
- S. centralis* Gertsch, 1941 - Panama
- S. belkini* (McDonald and Hogue, 1957) - California, U.S.A. — NEW COMBINATION
- S. cumbalensis* (Kraus, 1957) - Colombia — NEW COMBINATION
- S. sturmi* (Kraus, 1957) - Colombia — NEW COMBINATION
- S. macarensis* (Kraus, 1957) - Colombia — NEW COMBINATION
- S. gladiator* Remy, 1961 - Surinam

- S. surinamensis* Remy, 1961 - Surinam
S. vanderdrifti Remy, 1961 - Surinam
S. borregoensis (Briggs and Hom, 1966) - California, U.S.A. — NEW COMBINATION
S. brasiliensis (Kraus), in Kraus and Beck, 1967 - Colombia — NEW COMBINATION
S. mexicanus Rowland, 1971b - San Luis Potosí and Tamaulipas, México
S. mitchelli Rowland, 1971b - Tamaulipas, México
S. cookei Rowland, 1971b - San Luis Potosí, México
S. reddelli Rowland, 1971b - Tamaulipas, México
S. joshuensis (Rowland, 1971c) - California, U.S.A. — NEW COMBINATION
S. briggsi (Rowland, 1972) - California, U.S.A. — NEW COMBINATION
S. shoshonensis (Briggs and Hom, 1972) - California — NEW COMBINATION
S. goodnightorum (Rowland, 1973a) - Yucatán, México
S. orthoplax Rowland, 1973a - Chiapas, México
S. bartolo Rowland, 1973a - Nuevo León, México
S. firstmani Rowland, 1973a - Veracruz and ? Oaxaca, México
S. pecki Rowland, 1973a - Tabasco, México
S. sbordonii Brignoli, 1973 - Veracruz, México
S. arganoi Brignoli, 1973 - Chiapas, México
S. stewarti Rowland, 1973c - Oaxaca, México
S. moisi Rowland, 1973c - Oaxaca, México
S. lukensi Rowland, 1973c - Tamaulipas, México
S. negreai Dumitresco, 1973 - Cuba
S. rowlandi Dumitresco, 1973 - Cuba
S. lanceolatus Rowland, 1975b - Veracruz, México
S. trilobatus Rowland, 1975b - Tabasco, México
S. pallidus Rowland, 1975b - Veracruz, México
S. lacandonus Rowland, 1975b - Chiapas, México
S. infernalis Rowland, 1975b - Chiapas, México
S. silvino Rowland and Reddell, 1977 - Guatemala
S. orghidani Dumitresco, 1977 - Cuba
S. decui Dumitresco, 1977 - Cuba
S. gladiger Dumitresco, 1977 - Cuba
S. digitiger Dumitresco, 1977 - Cuba

The descriptions of species in this and subsequent reports include only those characters which have been determined to be of systematic importance. Many earlier descriptions have included characters which are either common to most or all species of schizomids, or which have proven upon more study to be so variable as to be of little value in diagnosing species. The following is a brief discussion of the characters which we use. Further discussion of these characters, particularly with respect to their phylogenetic importance, is deferred until the discussion on phylogeny.

Carapacial setae. The number of pairs of dorsal setae on the carapace is given for each species. Most species of schizomines possess three pairs of dorsal setae, but some may have either two or four pairs. In many species there has also been a reduction of the middle pair when three pairs are present.

Eyespots. Supposedly light sensory structures, referred to here as eyespots, are present only in the subfamily Schizominae. These structures may not be morphologically comparable to the lateral eyes of any other arachnid, but the histological details have not been

studied. In many cave-dwelling species the eyespots are absent or only barely visible, while in epigeal species they may range in shape from irregular to oval to triangular and are distinctly paler than the carapace.

Metapeltidium. The presence or absence of a suture dividing the metapeltidium has been used by many authors to distinguish genera. A split metapeltidium has been consistently used to characterize the genus *Trithyreus*. This study has revealed this character state to be present or absent in closely related species and, furthermore, transitional states occur in which the metapeltidial plates are separated only by a narrow suture. This character is, therefore, of only limited systematic value, and of use only at the specific level.

Abdominal tergal setae. The number of setae on the terga of the abdomen is given for each species. This character has proven to be quite consistent. Most species possess two setae on terga I-VII and four setae on terga VIII-IX, but variations do occur and are of specific value.

Anterior sternal setae. The number of setae on the anterior sternum of the prosoma is given for each species. This character, however, is somewhat variable and is of only limited taxonomic value.

Abdominal attenuation. Males of many species demonstrate varying degrees of attenuation of the distal abdominal segments. It is most highly developed in *Schizomus goodnightorum*, but occurs to a lesser degree in species from California, México, Guatemala and South America. The elongation may involve segments V-XII, or may only involve the pygidial segments, X-XII. A telescopic intercalation of the abdominal segments occurs in species with a highly attenuated abdomen. All species possessing an attenuated abdomen have elongate flagella and short, non-dimorphic pedipalps.

Spermathecae. Brignoli (1973) introduced the use of the spermathecae as a taxonomic character in the description of two Mexican species. Rowland (1973c) expressed reservations about the value of this character in diagnosing new species. Although Brignoli (1974) illustrated three additional species of schizomids to further show the importance of this character, he worked with very limited material and was unable to show the extent of variation which may occur in this character. Extensive study of the spermathecae has shown the value of this character in systematics, but it is unfortunately subject to transfigurations by preservation and mounting. Furthermore, in some species, it is highly variable; while in other instances, the spermathecae of related species may be essentially indistinguishable despite easily distinguishable male flagella. The spermathecae, however, should be illustrated when possible. We consider, however, that little can be gained by formally describing new taxa on the basis of the female alone. The following spermathecal traits have been found to be of value and are given for each species where the female is known: number of pairs, relative size of median and lateral pairs, presence or absence of terminal bulbs, and degree and location of sclerotization.

Posterodorsal abdominal process. This structure consists of a posterior emargination of the dorsal side of abdominal segment XII. It may project out over the base of the flagellum, or may only slightly protrude. In most species it is truncate, but it may also be pointed or gently rounded. It occurs only in males and may be completely absent in some species.

Male flagellum. The flagellum of the adult male has proven to be the most useful character in the identification of species. It is not affected by preservation and is usually highly consistent within populations. There is never the degree of intraspecific variation in male flagella that is found in female spermathecae.

Female flagellum. The articles of the female flagellum are joined either by segmentation and annulation or by annulation alone. The term segmentation does not suggest that the articles are derived from metameres, but only that they are separated from each other by a slight membranous region. Annulations, on the other hand, appear to represent lines of incomplete fusion of two flagellar articles.

Pedipalps. The pedipalps of many species of the subfamily Schizominae are sexually dimorphic. The pedipalps of females are all fairly similar and of limited value in species recognition. In males, however, the pedipalps are frequently elongated. This elongation may be a result of attenuation of the femora, patellae, and tibiae, or various combinations of these segments. The trochanter may or may not be produced apically. In some species the femora and patellae may bear an armature of spines. When the tibia is elongate it may bear a spur which is apposable to the tarsus-basitarsus. This spur may be either very prominent or small. In some species several stout spines or a prominent set occurs in the position of the spur. The characters of the male pedipalps have been found to be of systematic importance, especially when they are elongate. When large collections are available, however, it is occasionally found that there is some variation in the degree of elongation of the pedipalps. Although most males of any given species appear to have elongate pedipalps, there are occasionally males with pedipalps like the females.

Color. The color of schizomids ranges from extremely pale in the troglobitic species to brown or green. In the descriptions of the species the color is indicated by the terms brownish or greenish. These imprecise terms are used because of the variation in the degree of pigmentation in different individuals of a single species and between immatures and adults. It is also true that various parts of the body are somewhat different in color. The chelicerae are often a dark reddish color. The color of the carapace and dorsum of the abdomen is that which we refer to as greenish or brownish.

SYSTEMATICS

Seven species groups are recognized in the New World Schizomidae. Detailed descriptions of each group will be given in the text, but the accompanying comparisons table (Table 1) will serve to separate them. Keys are not included in this series of reports because they are of only limited value in accurately determining the identity of species in a group where most specimens collected will probably prove to be undescribed. The comparisons tables included for each species group should serve to distinguish the species within that group from one another and allow the student to determine the relationships of any new specimens obtained.

The species groups of *Schizomus* and their distribution are as follows: *dumitrescoae* group (Central America: Costa Rica; Antilles: Cuba, Jamaica, Haiti, Puerto Rico, Martinique); *simonis* group (Central America: Costa Rica, Panama; South America: Venezuela, Trinidad, Tobago, British Guiana); *brasiliensis* group (México: Oaxaca, Tabasco, Chiapas; Central America: Costa Rica; South America: Colombia, Ecuador, Brazil, Bolivia); *mexicanus* group (excluding *S. portoricensis*: United States: Texas; México: Nuevo León, Tamaulipas, San Luis Potosí, Guerrero, Veracruz, Oaxaca, Chiapas, Campeche, Quintana Roo, Yucatán; Central America: Guatemala, Belize. *S. portoricensis*: Bermuda, Florida, Antilles, southern México, Central America, northern South America, Galapagos Islands); *pecki* group (México: Veracruz, Oaxaca, Tabasco, Chiapas; Central America: Belize, Guatemala); *goodnightorum* group (México: Veracruz, Chiapas, Yucatán; Central America: Guatemala); *briggsi* group (United States: California, Arizona).

ORDER SCHIZOMIDA

Protoschizomidae Rowland

Protoschizomidae Rowland 1975b:1.

Description.—Carapace without eyespots; mesopeltidia large, separated by about 1/3 to 1/10 their greatest dimension; metapeltidium entire or divided. Abdomen with eight pairs of dorsoventral muscles. Flagellum segmented in females. Cheliceral serrula absent, but represented by a row of blunt, nearly hemispherical knobs; no row of closely situated setae at base of fixed digit (brush). Two teeth on fixed digit, basal one arising at an angle from ventral surface of basal segment. Ratio of pedipalpal claw length to dorsal length of tarsus-basitarsus 1:0.5 or 1:1; basitarsal spurs symmetrically placed, long, about 1/3 to 1/2 dorsal length of tarsus-basitarsus; “true spines” present. Trochanter IV about 2.2 times longer than wide; femur IV from about three to five times longer than deep.

Distribution.—México.

Protoschizomus Rowland

Protoschizomus Rowland 1975b:2. Type: *Agastoschizomus pachypalpus* Rowland 1973 (orig. desig.).

Description.—Carapace about 1 mm in length. Mesopeltidial plates separated by 1/3 their length; greatest length to width ratio of metapeltidial plates about 1.3:1. Abdominal sterna IV to VII about six times wider than long. Pedipalpal claw shorter than dorsal length of tarsus-basitarsus. Femur IV about three times longer than deep.

Distribution.—Tamaulipas and Colima, México.

Protoschizomus pachypalpus (Rowland) (Figs. 2, 5-7)

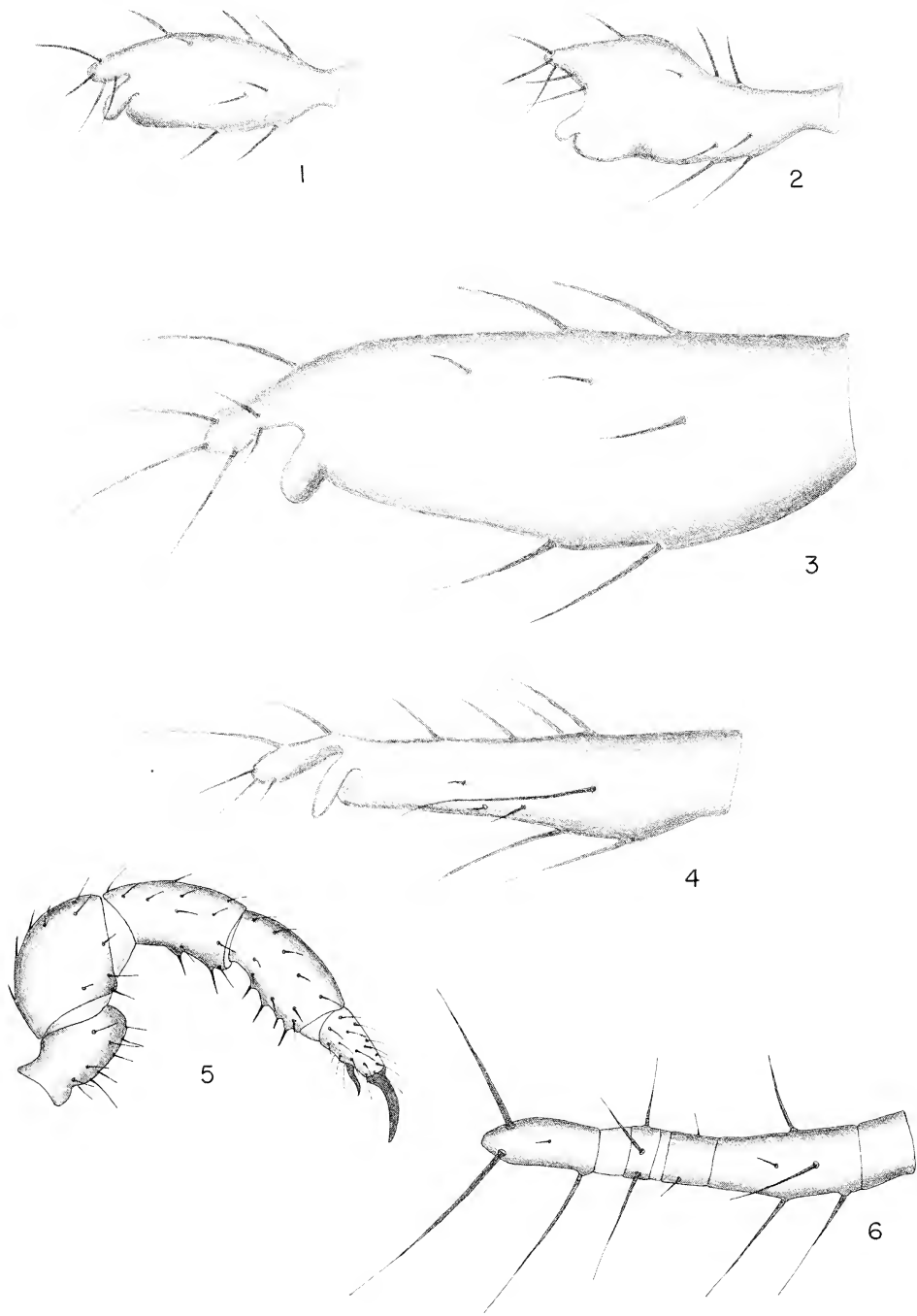
Agastoschizomus pachypalpus Rowland 1973a:8-10.

Protoschizomus pachypalpus: Rowland 1975b:2-4.

Description.—Male. Color brownish. Carapace with five pairs of dorsal and two apical setae. Eyespots absent. Metapeltidium divided medially into two plates. Anterior sternum with 11 entire setae. Abdominal terga I to II with two setae, terga III to VII with four setae, tergum VIII with 10 setae, tergum IX with four setae. Vestigial stigmata slightly darker than sterna. Flagellum long, club shaped, expanded distally, bearing 22 major setae. Pedipalpal trochanter not produced distally; femur and patella narrow proximally, expanded distally; tibia without mesal, subapical spur. Tarsal-basitarsal spurs about 2/5, claw about 4/5 length of tarsus-basitarsus. Tarsal segments of leg I of the following approximate proportions: 23-7-9-8-8-26. Other leg segment measurements given in Table 2.

Female. Flagellum with five articles.

Type data.—Holotype female and paratype juvenile taken at Nacimiento del Río Frío, 3 mi S Gómez Farías, Tamaulipas, México, 12 March 1969 (J. Reddell); two paratype



Figs. 1-6.—Parts of protoschizomids: 1-4, lateral views of male flagella: 1, *Protoschizomus occidentalis*; 2, *P. pachypalpus*; 3, *Agastoschizomus lucifer*; 4, *A. huitzmolotitlensis*; 5, lateral view of right pedipalp of female *P. pachypalpus*; 6, lateral view of female flagellum of *P. pachypalpus*

females and one paratype juvenile taken at Arroyo Nacimiento del Río Frío, Tamaulipas, México, 16 February 1970 (R. W. Mitchell); one paratype female taken at Gómez Farías, Tamaulipas, México, 6 January 1964 (J. Reddell, D. McKenzie, L. Manire). All specimens deposited in the AMNH.

Comparisons.—See under *P. occidentalis*.

Distribution.—This species is known from five localities in Tamaulipas, México.

Additional records .—México: Tamaulipas; 51.5 mi E Ciudad Victoria on Highway 70, 17 Oct. 1972 (B. L. Firstman, V. D. Roth), 1 male (AMNH), 60 mi S Ciudad Victoria, *ex* bromeliads, 17 November 1948 (H. B. Leech), 2 females (CAS).

Protoschizomus occidentalis Rowland
(Figs. 1, 7)

Protoschizomus occidentalis Rowland 1975b:4-5.

Description.—Male. Color brownish. Carapace with four pairs of dorsal and two apical setae. Eyespots absent. Metapeltidium divided medially into two plates. Anterior sternum with 11 entire setae. Abdominal terga I to II with two setae, terga III to IV with four setae, terga VIII to IX with six setae. Vestigial stigmata darker than sterna. Flagellum long, club shaped, expanded distally, bearing 22 major setae. Pedipalpal trochanter not produced distally; tibia with mesal, subapical spur. Tarsal-basitarsal spurs about 2/5, claw about 4/5 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 24-7-8-7-8-7-27. Other leg segment measurements given in Table 2.

Female unknown.

Type data.—Holotype male and paratype subadult female taken under a rock 13 mi SW Colima, México, 16 July 1972 (A. Jung) (AMNH).

Comparisons.—The two species of this genus can be separated most easily by comparison of the male flagella. It is distally more expanded in *P. pachypalpus* than in *P. occidentalis*. The carapace of *P. pachypalpus* has five pairs of dorsal setae whereas that of *P. occidentalis* has four pairs. The eighth abdominal tergum of the former has 10 setae, but there are only six in the latter. Other minor setational differences occur.

Distribution.—Known only from the type locality.

Agastoschizomus Rowland

Agastoschizomus Rowland 1971a:13. Type: *Agastoschizomus lucifer* Rowland 1971 (monotypy); Rowland 1973b:202; Rowland 1975b:5.

Description.—Carapace about 2 to 3 mm in length. Mesopeltidial plates separated by 1/10 their greatest dimension; greatest length to greatest width ratio of metapeltidial plates about 1:1. Abdominal sterna IV to VII about three times wider than long. Pedipalpal claw longer than dorsal length of tarsus-basitarsus, ratio of about 1.1:1; tarsal-basitarsal spurs about 1/2 dorsal length of tarsus-basitarsus. Femur IV about five times longer than deep.

Distribution.—San Luis Potosí, México.

Agastoschizomus lucifer Rowland
(Figs. 3, 7)

Agastoschizomus lucifer Rowland 1971a:13-17; Reddell and Mitchell 1971:145; Dumitresco 1973:282; Rowland 1973a:10; Rowland 1973b:197, 202; Rowland 1973c:136; Reddell 1973:33, 38; Reddell and Elliott 1973:171; Brignoli 1974:150; Rowland 1975b:6,8,9,10, Rowland and Reddell 1977:81-82.

Description.—Male. Color brownish. Carapace with two pairs of dorsal and three apical setae. Eyespots absent. Metapeltidium divided medially into two plates by a very narrow suture. Anterior sternum with nine entire setae. Abdominal terga I to V with two setae, terga VI to VII with four setae, terga VIII to IX with six setae. Vestigial stigmata darker than sterna. Flagellum long, cylindrical, apically modified. Pedipalpal trochanter not produced distally; femur and patella bearing several stout spines; tibia without mesal, subapical spur. Tarsal-basitarsal spurs about 2/3, claw about 7/6 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 60-19-18-16-21-56. Other leg segment measurements given in Table 2.

Female. Flagellum with five articles.



Fig. 7.—Map showing distribution of the protoschizomids: 1, *Protoschizomus occidentalis*; 2, *P. pachypalpus*; 3, *Agastoschizomus lucifer*; 4, *A. huitzmolotitlensis*.

Type data.—Holotype male taken in Sótano de la Tinaja, 10 km NNE Ciudad Valles, San Luis Potosí, México, 9 April 1966 (J. Fish, D. McKenzie); allotype female and paratype female taken in Sótano de Yerbaniz, 22.5 km N Ciudad Valles, San Luis Potosí, México, 28 March 1970 (W. Elliott); paratype male taken in Sótano de Yerbaniz, 8 January 1971 (W. Elliott). All specimens deposited in the AMNH.

Comparisons.—See under *A. huitzmolotitlensis*.

Remarks.—See under *A. huitzmolotitlensis*.

Distribution.—Three caves in the southern Sierra de El Abra north of Valles, San Luis Potosí, México.

Additional records.—See Rowland and Reddell (1977) for other records.

Agastoschizomus huitzmolotitlensis Rowland
(Figs. 4, 7)

Agastoschizomus huitzmolotitlensis Rowland 1975b:6, 8-10; Rowland and Reddell 1977:81-82.

Schizomus sp.: Reddell 1967:106; Reddell, 1971:28 [Sótano de Huitzmolotitla record only].

Description.—Male. Color brownish. Carapace with one pair of dorsal and three apical setae. Eyespots absent. Metapeltidium undivided, slightly emarginate posteriorly. Anterior sternum with 11 entire setae. Abdominal terga I to IV with two setae, terga V to VII with four setae, terga VIII with 10 setae, and terga IX with six setae. Vestigial stigmata slightly darker than sterna. Flagellum long, cylindrical, bearing 18 major setae, apically modified. Pedipalpal trochanter not produced distally; femur and patella bearing several stout spines; tibia without mesal, subapical spur. Tarsal-basitarsal spurs about 2/3, claw about 7/6 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 45-13-14-14-15-13-43. Other leg measurements given in Table 2.

Female unknown.

Type data.—Holotype male taken in Sótano de Huitzmolotitla, 2 km SW Tlamaya, and approximately 10 km N Xilitla, San Luis Potosí, México, 24 January 1964 (Terry Raines, Tommy Phillips), in mud room 9000 ft. from entrance (AMNH).

Comparisons.—*A. huitzmolotitlensis* is somewhat smaller and displays more advanced troglobitic facies than *A. lucifer*. The male flagellum in particular is relatively much narrower basally in *A. huitzmolotitlensis*. The presence of 2 pair of dorsal carapacial setae in *A. lucifer* as opposed to 1 pair in *A. huitzmolotitlensis* also separates the two species. They are also readily separable on the basis of the setation of the abdominal terga.

Distribution.—Known only from the type locality.

Remarks.—The two species of the genus *Agastoschizomus* are remarkable troglobites and are by far the largest species in the order. Their pronounced morphological similarities indicate that they are derived from an immediate common ancestor morphologically very similar to both. The extreme size and pedipalpal configurations common to these species and to their hypothetical ancestor are probably not due entirely to adaptations to cave environments.

Schizomidae Hansen and Sørensen

Tartarides Cambridge 1872:410 (nom. obl.).
Schizonotidae Thorell 1888:358 [nom. correct. Pocock 1893 (ex Schizonotoidae Thorell 1888, nom. imperf.)] (name based on junior homonym).
Hubbardiidae Cook 1899:429 (nom. obl.) (name based on junior subjective synonym).
Schizomidae Hansen and Sørensen 1905:4 [nom. correct. Gravely 1915 (ex Schizomoidae Hansen and Sørensen 1905, nom. imperf.)].
Schizomidae Chamberlin 1922:11 (jun. prim. hom.).

Table 1.--Comparisons of the New World species groups of the genus *Schizomus*. See the Introduction for explanation of characters.

CHARACTER	dumitres- coae	simonis	brasil- iensis	mexi- canus	pecki	goodni- ghtorum	briggsi
DORSAL SETAE	2-3	2-3	3-4	2-3	2-3	3-4	3-4
METAPEL- TIDIUM	entire	entire	split or entire	entire	entire	entire	split or entire
COLOR	brown or green	brown or green	brown or green	brown or green	brown	brown	brown or green
SPERMA- THECAE	M < L	M < L	M = L	M > L	M > L	M > L	multiple
ART. FEM. FLAGELLUM	4	4	3	3	3	3	4
CARAPACE LENGTH	.96-1.37	1.07-1.34	.91-1.48	.98-1.37	1.31-1.74	.89-1.42	1.18-1.52
ABDOMINAL ELONGATION	none	present	none	none	none	present	none or present
ABDOMINAL PROCESS	present	present	present	absent	absent	absent	present
PEDIPALPAL DIMORPHISM	slight to strong	none	slight to strong	none to strong	none	none	none to strong
SHAPE MALE FLAGELLUM	bulbous	long	bulbous	bulbous	bulbous	long	long or bulbous

Description.—Carapace with or without eyespots, mesopeltidia small, separated by about $1/2$ to $2/3$ their greatest dimension; metapeltidium entire or divided. Abdomen with seven pairs of dorsoventral muscles. Flagellum segmented or unsegmented in females. Cheliceral serrula present, a row of closely situated setae also present at base of fixed digit (brush). Three or five to nine teeth present on fixed digit, basal one arising gradually from ventral surface of basal segment. Ratio of pedipalpal claw length to tarsal-basitarsal length from about 1:4 to 1:1.2; tarsal-basitarsal spurs asymmetrically placed, medium to short, about $1/4$ to $1/5$ dorsal length of tarsus-basitarsus; “true spines” present or absent. Trochanter IV about 1.4 or 2.2 times longer than wide, femur IV from about 2.6 to 4.1 times longer than deep.

Distribution.—Present in all tropical and certain subtropical and temperate areas.

Schizominae Hansen and Sörensen

Schizomidae Hansen and Sörensen 1905:4.

Schizominae Rowland 1973a:200 [nom. transl. Rowland 1973a (ex Schizomidae Hansen and Sörensen 1905)]; Rowland 1975:11.

Description.—Carapace with or without eyespots; mesopeltidia divided by about equal to their greatest dimension; metapeltidium entire or divided. Flagellum unsegmented in females. Fixed digit of chelicerae with five to nine teeth. Ratio of pedipalpal claw to tarsal-basitarsal length about 1:4 to 1:1.2; tarsal-basitarsal spurs asymmetrically placed, short, about $1/5$ dorsal length of tarsus-basitarsus; “true spines” absent. Trochanter IV about 1.4 times longer than wide, femur IV about 2.6 times longer than deep.

Distribution.—Same as for the family.

Schizomus Cook

Nyctalops Cambridge 1872:410 (jun. hom.). Type: *N. crassicaudata* (sub. des., Cook 1899).

Schizonotus Thorell 1888:358 (jun. hom) [nom. subst. pro *Nyctalops* (non *Nyctalops* Wagler 1832)]; Kraepelin 1897:50; Kraepelin 1899:233.

Tripeltis Thorell 1889:554 (jun. hom.). Type: *T. grassil* (orig. des.).

Trithyreus Kraepelin 1899:234 [nom. subst. pro *Tripeltis* (non *Tripeltis* Cope 1886)] in part.

Triplomus Cook 1899:250 (jun. obj. syn.) [nom. subst. pro *Tripeltis* (non *Tripeltis* Cope 1886)].

Hubbardia Cook 1899:250 (jun. subj. syn.). Type: *H. pentapeltis* Cook (monotypy).

Artacarus Cook 1899:254 (jun. subj. syn.). Type: *A. liberiensis* Cook (monotypy).

Schizomus Cook 1899:249 [nom. subst. pro *Schizonotus* (non *Schizonotus* Ratzeburg 1852)].

Stenochrus Chamberlin 1922:11 (jun. subj. syn.). Type: *S. portoricensis* Chamberlin (monotypy).

Heteroschizomus Rowland 1973:1 (jun. subj. syn.). Type: *H. goodnightorum* Rowland (monotypy).

Description.—Same as that for the subfamily.

Distribution.—Same as that for the family.

DUMITRESCOAE GROUP

Description.—Members of this group are characterized by moderate to large size (0.96-1.37 mm carapacial length). The color varies from brown to green. The eyespots vary from irregular to triangular and indistinct to well defined. The carapace may have two to four pairs of dorsal and two apical setae. The arrangement of the setae may be variable and the middle pair may be smaller than the others. The abdomen shows no elongation of posterior segments. The pygidial segments are very shallow. The males of most species have a well-developed posterodorsal abdominal process, which is usually truncate, but may vary within the species from truncate to round. The flagellum, with two exceptions, bears a central to subapical median depression. Several species have bilateral projections arising from above and beside this depression. In some species the flagellum is robust and globose, but is usually small. The female flagellum is moderate to

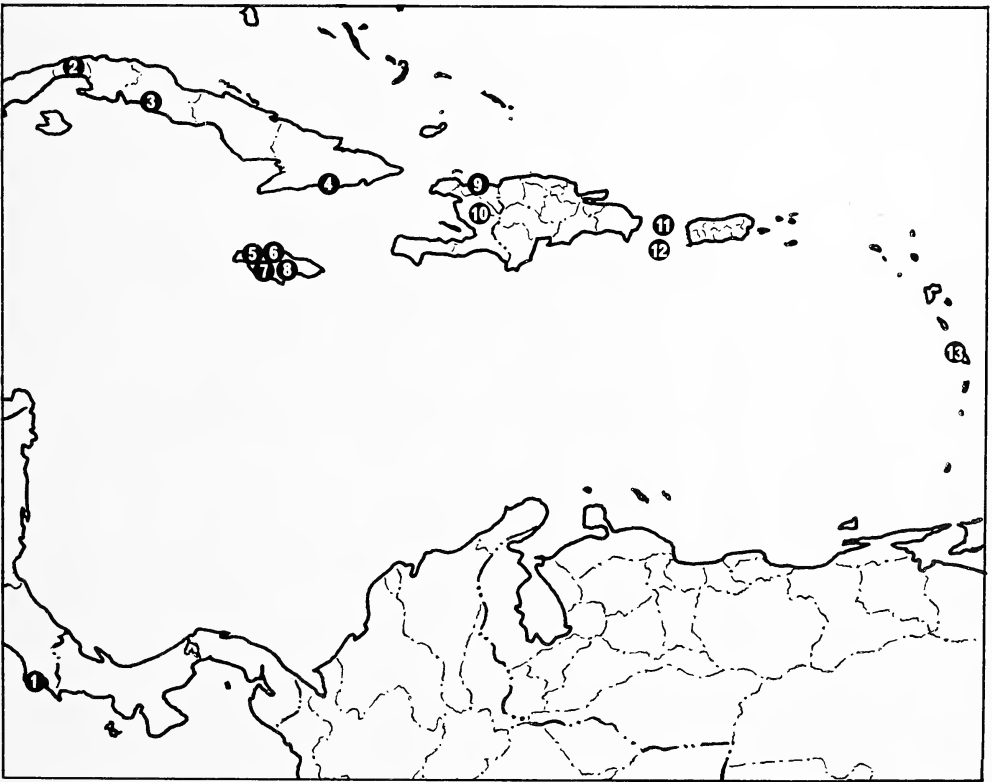


Fig. 8.—Map showing distribution of schizomids of the *dumitrescoae* group: 1, *Schizomus dumitrescoae*; 2, *S. decui*; 3, *S. biconourus*; 4, *S. gladiger*; 5, *S. cousinensis*; 6, *S. primibiconourus*; 7, *S. peckorum*; 8, *S. viridis*; 9, *S. brevipatellatus*; 10, *S. longipalpus*; 11, *S. desecheo*; 12, *S. monensis*; 13, *S. insignis*.

long (0.19-0.36 mm), and composed of four articles. The spermathecae are characterized by elongation of the laterals and reduction of the medians. In a few species the lateral spermathecae are very large and terminate in a spherical, sclerotized bulb. In other species the median spermathecae are reduced. The pedipalps are always sexually dimorphic. Males of certain species have highly variable pedipalps. The trochanter is usually in some way elaborated; and the femur, patella, and tibia are usually elongate, but the tibia has no spur apposable to the tarsus-basitarsus.

Distribution.—Central America: Costa Rica. Antilles: Cuba, Jamaica, Haiti, Puerto Rico, Martinique.

Remarks.—Species which probably belongs in this group, but which we have not seen, are *Schizomus negreai* Dumitresco, and *S. digitiger* Dumitresco. On the basis of the descriptions *S. negreai* appears to be most closely related to *S. biconourus*, another Cuban species; while *S. digitiger* appears to be most similar to *S. longipalpus* from Haiti. It has also not been possible to examine *S. dispar* Hansen, which may also belong in this group. It is known only by females and details of its anatomy are inadequately described. It was collected in Martinique and may be a close relative of *S. insignis*. See Table 3 for characters used in separating the species of the *dumitrescoae* group.

Subordinate taxa.—*Dumitrescoae* complex: *S. dumitrescoae*, *S. decui*; *primibiconourus* complex: *S. cousinensis*, *S. primibiconourus*, *S. longipalpus*, *S. brevipatellatus*; *viridis* complex: *S. gladiger*, *S. monensis*, *S. desecheo*, *S. biconourus*, *S. insignis*, *S. peckorum*, *S. viridis*.

Table 2.—Measurements (mm) of species of the family Protoschizomidae: 1, one male, *Protoschizomus pachypalpus*; 2, one female, *P. pachypalpus*; 3, one male, *P. occidentalis*; 4, four males, *Agastoschizomus lucifer*; 5, four females, *A. lucifer*; 6, one male, *A. huitzmolotitlensis*. Except as otherwise noted all measurements are of lengths.

	1	2	3	4	5	6
Carapace	1.24	1.16	1.16	2.29-2.41	2.84-3.21	1.84
Flagellum						
Length	0.61	0.46	0.53	1.37-1.40	1.26-1.43	0.98
Width	0.28	-	0.25	0.41-0.42	-	0.26
Leg I						
Femur	0.97	0.79	1.02	3.36-3.51	3.48-3.76	2.53
Patella	0.80	0.71	0.80	3.99-4.14	3.80-4.16	3.11
Tibia	0.71	0.69	0.74	3.24-3.38	2.90-3.30	2.50
Tarsus-basitarsus	1.05	0.80	0.99	1.97-2.10	2.04-2.16	1.54
Leg II						
Femur	1.06	0.70	1.07	2.46-2.66	2.46-3.01	1.83
Patella	0.44	0.39	0.48	1.32-1.40	1.38-1.56	1.05
Tibia	0.34	0.34	0.38	1.69-1.86	1.75-1.97	1.35
Basitarsus	0.52	0.44	0.54	1.18-1.30	1.25-1.33	0.87
Leg III						
Femur	0.95	0.80	0.98	2.41-2.62	2.54-2.90	1.88
Patella	0.53	0.44	0.48	1.13-1.20	1.11-1.43	0.96
Tibia	0.37	0.36	0.36	1.68-1.72	1.74-1.92	1.24
Basitarsus	0.77	0.66	0.70	1.41-1.45	1.51-1.54	1.04
Leg IV						
Femur	0.89	0.81	0.83	3.18-3.34	3.32-3.62	2.24
Patella	0.38	0.30	0.35	1.51-1.54	1.57-1.77	1.15
Tibia	0.43	0.35	0.41	2.61-2.68	2.62-2.86	1.90
Basitarsus	0.63	0.49	-	1.75-1.83	1.75-2.10	1.42

Table 3.--Comparisons of the members of the *dumitrescoae* group. See the Introduction for explanation of characters.

CHARACTER	decuri	dumitrescoae	cousinensis	primitivobiconurus	longipalpus	brevipatellatus	gladiger	monensis	desecheo	biconurus	insignis	peckorum	viridis
DORSAL SETAE	2	2M-4F	2M-3F	2	2	2	3	3	3	3	3	3	3
STERNAL SETAE	13	10	11	11	13	13	12	11	10	12	11	13	13
COLOR	brown	brown	brown	brown	brown	brown	green	green	green	green	green	green	green
MALE PEDIPALP	long thin	long thin	long thin	long robust	long robust	long thin	short robust	short robust	short robust	short robust	long thin	short robust	long robust
ABDOMINAL PROCESS	slight	slight	slight	slight	slight	slight	round	truncate	truncate	pointed	truncate	truncate	round truncate
EYESPOTS	indistinct	indistinct	indistinct	oval	angular	indistinct	oval to angular	indistinct	angular	oval to angular	short broad	oval to angular	angular
SPERMATHECAE	?	L 2X M	L 2X M	?	?	?	L 2X M	L 1.5X M	?	L ±= M	L 4X M	L 5X M	L 2-3X M
CARAPACE LENGTH	1.10	.96	1.08	1.03	1.29	1.36	.96	1.16	1.16	1.00	1.00	1.26	1.37
LENGTH FEM. FLAGELLUM	?	.30	.30	?	?	?	.23	.33	?	.23	.19	.34	.36
PIT MALE FLAGELLUM	single median	single median	double median	single median	single median	double lateral	single median	vague	vague	single median	single median	single median	single median

Schizomus dumitrescoae, new species

(Figs. 8-9, 27, 49, 63-64)

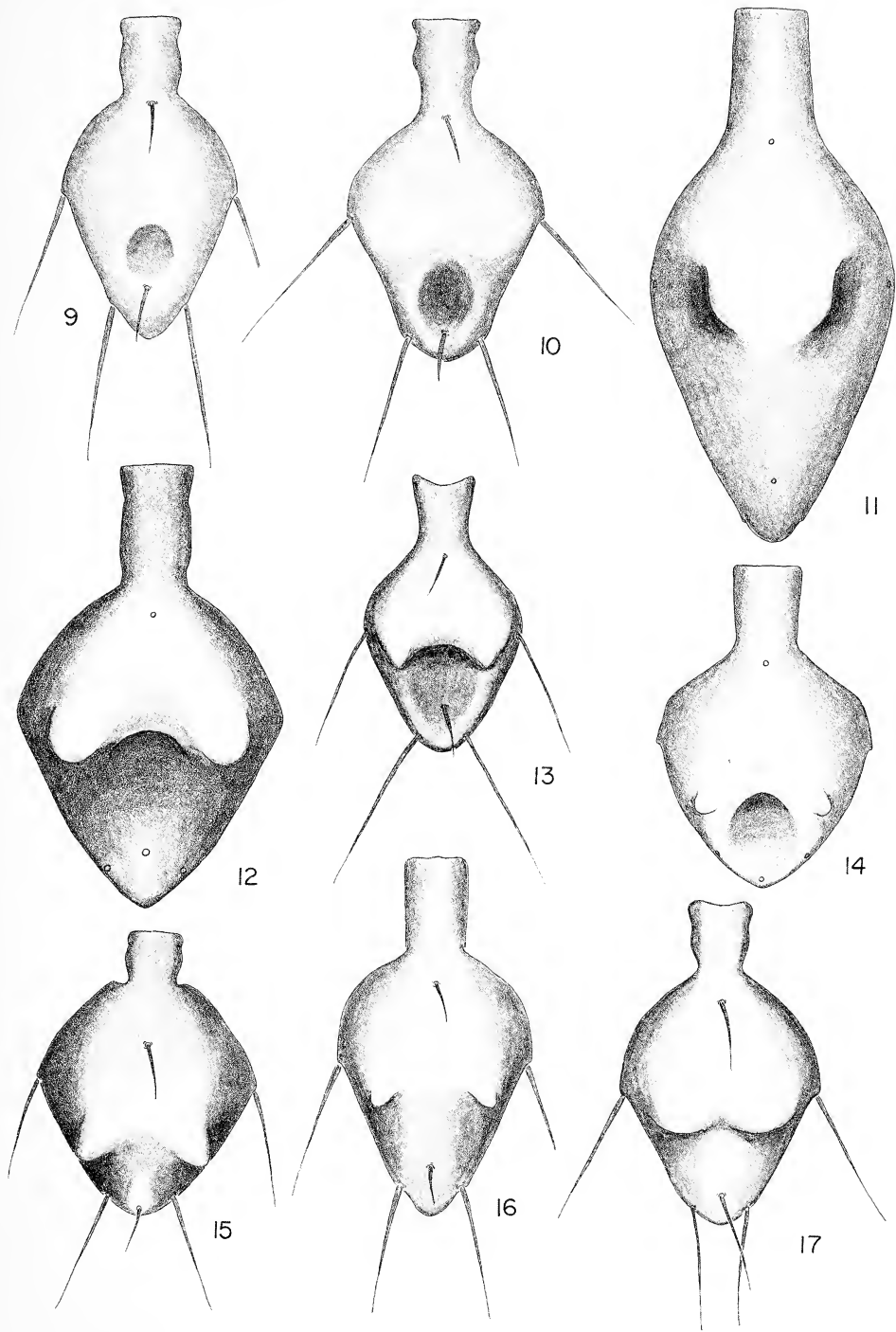
Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots indistinct, oblong, with irregular margins. Anterior sternum with 10 entire setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with slight evidence of posterodorsal process. Vestigial stigmata hardly distinct in color from sterna. Flagellum lanceolate, dorsally compressed, with a single median depression subapically. Pedipalpal trochanter much elongate, but not produced distally; femur, patella, and tibia all elongate, no segments with additional armature. Tarsal-basitarsal spurs about 1/10, claw about 1/3 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 31-5-6-6-8-8-16. Other leg segment measurements given in Table 4.

Female. Carapace with four pairs of dorsal setae. Flagellum with four sections. Pedipalps not elongate. Lateral spermathecae about twice as long as medians, very long, recurved, the tips with enlarged, sclerotized bulbs, medians very weak, with no areas of heavy sclerotization.

Type data.—Holotype male, allotype female, and paratype male taken at Coto, Costa Rica, 5 July 1957 (E. Dixon); paratype male, female, and two immatures taken at Coto, Costa Rica, 4 September 1957 (E. Dixon); paratype female and two immatures taken at Golfito, Costa Rica, 27 August 1957 (E. Dixon). All specimens deposited in the AMNH.

Table 4.—Measurements (mm) of five species of the *dumitrescoae* group: 1, one male, *Schizomus decui*; 2, three males, *S. dumitrescoae*; 3, two females, *S. dumitrescoae*; 4, two males, *S. cousinensis*; 5, two females, *S. cousinensis*; 6, three males, *S. primibiconourus*; 7, three males, *S. longipalpus*. Except as otherwise noted all measurements are of lengths.

	1	2	3	4	5	6	7
Carapace	1.10	0.93-0.98	0.95-0.98	0.92-1.18	1.06-1.08	1.01-1.07	1.24-1.35
Flagellum							
Length	1.13	0.33-0.34	0.30	0.36-0.37	0.30-0.30	0.33-0.34	0.44-0.47
Width	0.20	0.17-0.19	-	0.19-0.22	-	0.22-0.26	0.26-0.27
Leg I							
Femur	1.23	0.79-0.89	0.77-0.82	0.97-1.26	0.90-0.94	1.01-1.04	1.50-1.56
Patella	1.49	0.59-0.68	0.61-0.62	1.16-1.56	1.11-1.13	1.28-1.38	1.87-1.96
Tibia	1.10	0.54-0.58	0.51-0.58	0.84-1.10	0.80-0.82	0.98-1.03	1.36-1.39
Tarsus-basitarsus	0.82	0.82-0.89	0.82-0.86	0.77-0.90	0.71-0.72	0.80-0.83	1.03-1.12
Leg II							
Femur	0.76	0.98-1.09	0.87-0.93	0.68-0.85	0.66-0.68	0.69-0.72	1.04-1.10
Patella	0.43	0.34-0.39	0.35-0.36	0.40-0.52	0.39-0.40	0.36-0.38	0.62-0.63
Tibia	0.50	0.25-0.27	0.25-0.26	0.43-0.53	0.39-0.42	0.39-0.40	0.68-0.72
Basitarsus	0.45	0.37-0.44	0.39-0.41	0.38-0.50	0.38-0.39	0.41-0.47	0.61-0.65
Leg III							
Femur	0.65	0.69-0.80	0.65-0.69	0.38-0.74	0.57-0.60	0.58-0.65	0.84-0.91
Patella	0.30	0.33-0.39	0.35-0.36	0.25-0.35	0.25-0.28	0.30-0.38	0.43-0.44
Tibia	0.34	0.27-0.30	0.25-0.26	0.30-0.39	0.29-0.31	0.31-0.33	0.46-0.49
Basitarsus	0.39	0.54-0.60	0.55-0.59	0.36-0.53	0.36-0.39	0.39-0.46	0.58-0.63
Leg IV							
Femur	1.05	0.65-0.68	0.64-0.64	0.91-1.11	0.91-0.97	1.00-1.06	1.27-1.39
Patella	0.48	0.32-0.38	0.35-0.36	0.42-0.56	0.43-0.45	0.39-0.44	0.65-0.65
Tibia	0.76	0.32-0.39	0.36-0.36	0.61-0.74	0.60-0.64	0.62-0.69	0.82-0.93
Basitarsus	0.65	0.50-0.54	0.50-0.52	0.54-0.71	0.54-0.54	0.56-0.62	0.84-0.86



Figs. 9-17.—Dorsal views of male flagella of the *dumitrescoae* group: 9, *Schizomus dumitrescoae*; 10, *S. decui*; 11, *S. brevipatellatus*; 12, *S. longipalpus*; 13, *S. cousinensis*; 14, *S. primibiconourus*; 15, *S. gladiger*; 16, *S. desecheo*; 17, *S. monenis*.

Comparisons.—See under *S. decui*.

Distribution.—This species is known from Coto and Golfito, Costa Rica.

Etymology.—This species is named after Margareta Dumitresco of the Institut de Spéologie “Emile Racovitza”, Roumanie, in recognition of her contributions to the study of the Schizomida.

Remarks.—*S. dumitrescoae* is unusual in having a different number of dorsal carapacial setae in males and females. The fact that males and females have been collected together on two occasions, however, supports the assumption that they actually represent sexes of the same species.

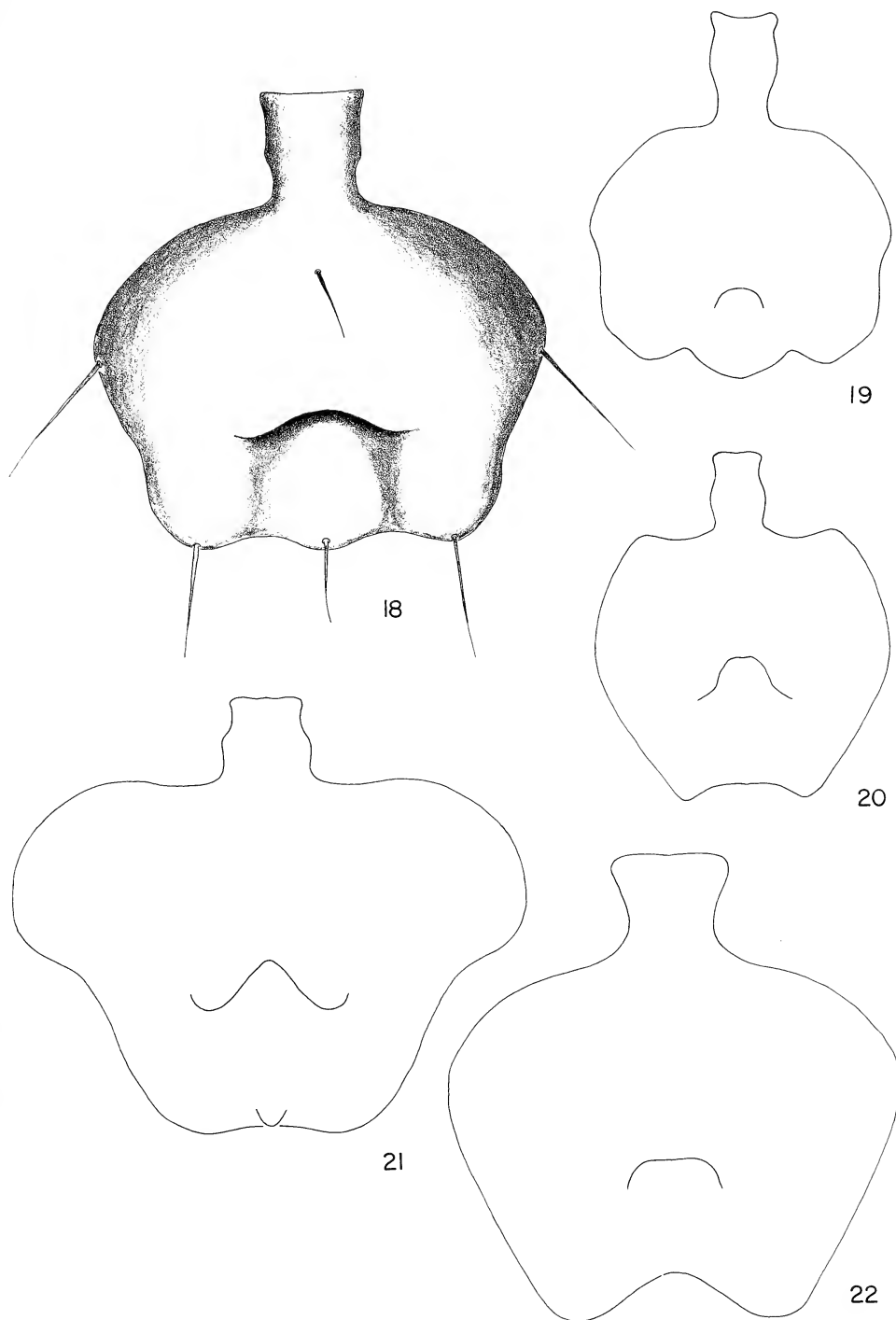
Schizomus decui Dumitresco
(Figs. 8, 10, 26, 47)

Schizomus decui Dumitresco, 1977:147, 151-153, 154, 155, 156, 157, figs. 4-5.

Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots indistinct, oblong with irregular margins. Anterior sternum with 13 entire setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with slight posterodorsal process. Vestigial stigmata slightly darker than sterna. Flagellum lanceolate, dorsally compressed, with a single median depression subapically. Pedipalpal trochanter much elongate, not produced distally; femur, patella, and tibia all elongate, no

Table 5.—Measurements (mm) of five species of the *dumitrescoae* group: 1, one male, *S. brevipatellatus*; 2, two males, *S. gladiger*; 3, two females, *S. gladiger*; 4, one male, *S. monensis*; 5, two females, *S. monensis*; 6, one male, *S. desecheo*; 7, two males, *S. biconourus*; 8, one female, *S. biconourus*. Except as otherwise noted all measurements are of lengths.

	1	2	3	4	5	6	7	8
Carapace	1.36	0.92-0.93	0.99-1.01	1.16	1.22-1.28	1.16	0.96-1.04	0.96
Flagellum								
Length	0.55	0.30-0.31	0.23-0.23	0.43	0.33-0.33	0.39	0.34-0.35	0.23
Width	0.27	0.23-0.23	-	0.26	-	0.20	0.33-0.36	-
Leg I								
Femur	1.60	0.89-0.92	0.85-0.87	1.32	1.28-1.33	1.10	0.94-1.00	0.80
Patella	2.11	1.09-1.15	1.02-1.03	1.66	1.59-1.65	1.28	1.16-1.24	0.96
Tibia	1.59	0.79-0.84	0.75-0.77	1.26	1.21-1.24	1.01	0.88-0.93	0.75
Tarsus-basitarsus	1.12	0.66-0.67	0.66-0.68	0.97	0.90-0.92	0.82	0.72-0.72	0.66
Leg II								
Femur	1.21	0.61-0.65	0.62-0.67	0.86	0.86-0.89	0.77	0.64-0.70	0.57
Patella	0.66	0.33-0.36	0.34-0.36	0.48	0.49-0.51	0.41	0.38-0.40	0.33
Tibia	0.82	0.38-0.41	0.36-0.38	0.55	0.56-0.57	0.49	0.38-0.43	0.33
Basitarsus	0.67	0.33-0.37	0.32-0.33	0.53	0.54-0.54	0.42	0.36-0.37	0.31
Leg III								
Femur	1.03	0.52-0.53	0.54-0.54	0.73	0.77-0.77	0.66	0.55-0.56	0.44
Patella	0.48	0.24-0.26	0.26-0.26	0.35	0.36-0.37	0.31	0.26-0.27	0.23
Tibia	0.57	0.27-0.28	0.26-0.29	0.44	0.46-0.47	0.39	0.30-0.31	0.26
Basitarsus	0.69	0.35-0.36	0.35-0.35	0.55	0.52-0.54	0.44	0.36-0.40	0.31
Leg IV								
Femur	0.77	0.85-0.89	0.87-0.88	1.21	1.23-1.26	1.07	0.87-0.93	0.82
Patella	0.34	0.38-0.40	0.38-0.41	0.53	0.53-0.55	0.47	0.39-0.48	0.37
Tibia	1.09	0.55-0.61	0.58-0.58	0.81	0.86-0.88	0.75	0.54-0.61	0.55
Basitarsus	0.96	0.49-0.50	0.50-0.51	0.72	0.77-0.79	0.62	0.50-0.55	0.47



Figs. 18-22.—Dorsal views of male flagella of *S. viridis* from various localities: 18, the type locality; 19, Pedro Great Cave, Clarendon Parish; 20, Jackson Bay Cave, Clarendon Parish; 21, Cave River Cave, St. Ann Parish; 22, Thatchfield Light Hole, St. Ann Parish.

segments with additional armature, though single enlarged setae apposes the tarsus-basitarsus. Tarsal-basitarsal spurs about 1/10, claw about 1/4 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 39-6-8-7-8-9-22. Other leg segment measurements given in Table 4.

Female. We have not seen the female of this species, but it is described by Dumitresco (1977).

Type locality.—Cueva La Pluma, Provincia de Matanzas, Cuba.

Specimen examined.—One male taken at San Antonio de los Baños, Habana, Cuba, 4 June 1972 (Luis F. de Armas) (IZACC).

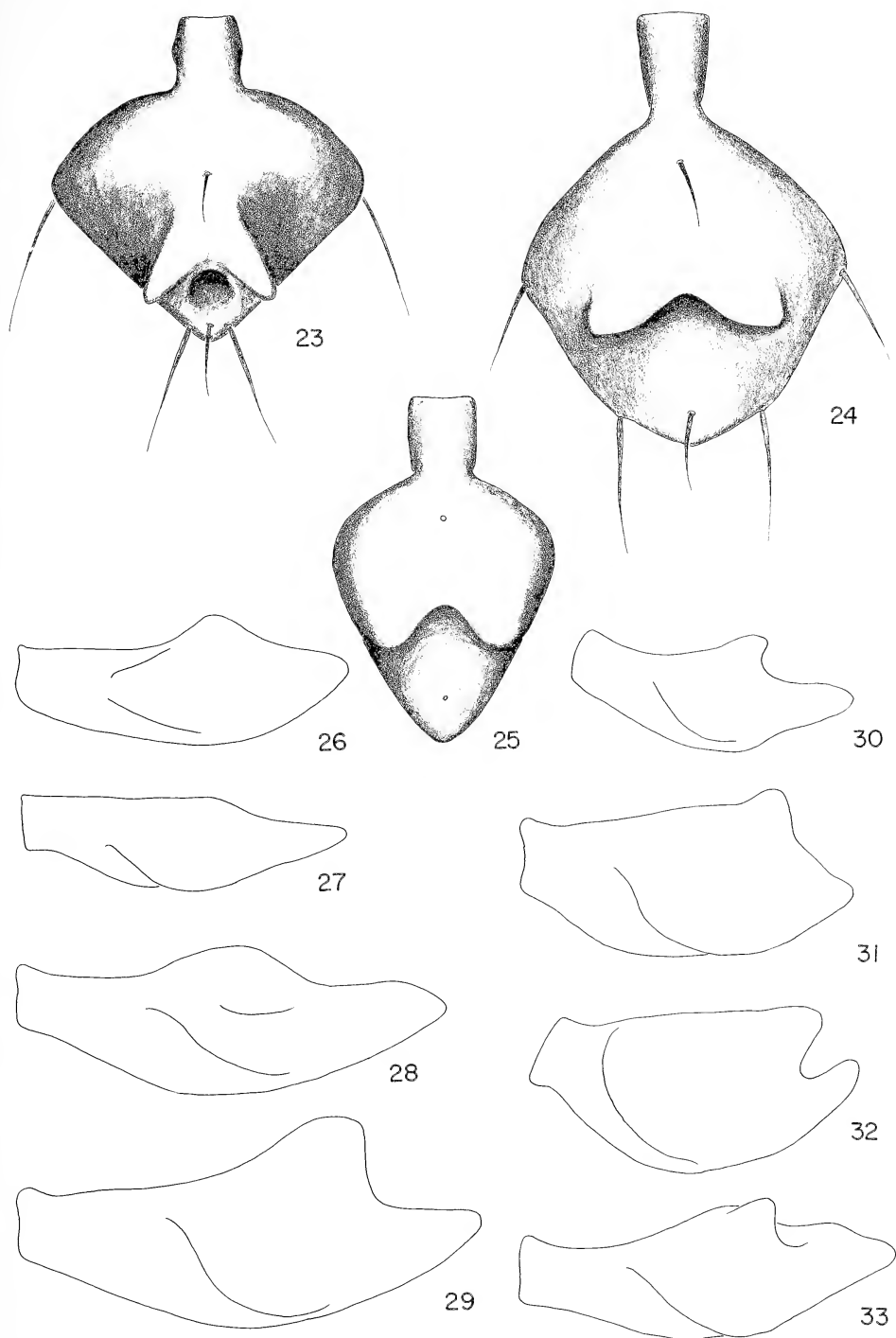
Comparisons.—*S. decui* is larger and has proportionately longer pedipalps and first legs than *S. dumitrescoae* its closest relative. The variability in pedipalp length in other species, however, and lack of adequate sample size of either of these species make diagnosis on the basis of pedipalp length questionable. The greater development of basolateral elevations on the flagellum of *S. decui* is probably more reliable. *S. dumitrescoae* lacks the large tibial seta on the pedipalps which apposes the tarsus-basitarsus in *S. decui*.

Distribution.—Known only from Cueva La Pluma, Matanzas, and San Antonio de los Baños, Habana, Cuba.

Remarks.—Although we have not seen the type specimens of this species, there is little doubt but that the specimen from San Antonio de los Baños is conspecific with *S. decui*. The shape of the male flagellum and pedipalps of the specimen examined agrees very closely with the drawings of these structures in Dumitresco (1977).

Table 6.—Measurements (mm) of three species of the *dumitrescoae* group: 1, one male, *S. insignis*; 2, one female, *S. insignis*; 3, two males, *S. peckorum*; 4, three females, *S. peckorum*; 5, three males, *S. viridis*; 6, three females, *S. viridis*. Except as otherwise noted all measurements are of lengths.

	1	2	3	4	5	6
Carapace	1.01	1.00	1.24-1.31	1.22-1.28	1.31-1.35	1.38-1.42
Flagellum						
Length	0.37	0.19	0.46-0.49	0.33-0.37	0.43-0.47	0.35-0.36
Width	0.23	-	0.35-0.37	-	0.40-0.44	-
Leg I						
Femur	1.03	0.86	1.34-1.54	1.24-1.35	1.25-1.38	1.20-1.24
Patella	1.26	1.06	1.75-1.86	1.45-1.62	1.52-1.69	1.36-1.48
Tibia	0.87	0.75	1.19-1.35	1.07-1.13	1.10-1.21	1.03-1.07
Tarsus-basitarsus	0.71	0.66	0.97-1.09	0.83-0.87	0.99-1.00	0.88-0.93
Leg II						
Femur	0.71	0.65	0.93-1.07	0.89-0.94	0.92-0.93	0.92-0.96
Patella	0.40	0.37	0.51-0.57	0.45-0.51	0.51-0.56	0.53-0.55
Tibia	0.44	0.37	0.58-0.66	0.52-0.58	0.55-0.56	0.54-0.56
Basitarsus	0.40	0.33	0.64-0.68	0.51-0.57	0.51-0.61	0.50-0.54
Leg III						
Femur	0.62	0.55	0.77-0.89	0.76-0.82	0.78-0.86	0.79-0.85
Patella	0.28	0.26	0.36-0.42	0.36-0.38	0.35-0.41	0.33-0.39
Tibia	0.26	0.25	0.43-0.44	0.40-0.43	0.40-0.46	0.39-0.44
Basitarsus	0.40	0.37	0.58-0.65	0.52-0.55	0.54-0.59	0.51-0.52
Leg IV						
Femur	0.96	0.93	1.30-1.43	1.00-1.24	1.27-1.34	1.27-1.31
Patella	0.44	0.41	1.09-1.28	0.54-0.56	0.58-0.63	0.58-0.62
Tibia	0.64	0.51	0.82-0.97	0.76-0.85	0.82-0.87	0.80-0.86
Basitarsus	0.59	0.54	0.75-0.87	0.71-0.74	0.75-0.79	0.73-0.75



Figs. 23-33.—Male flagella of the *dumitrescoae* group: 23-25, dorsal view: 23, *S. biconourus*; 24, *S. peckorum*; 25, *S. insignis*; 26-33, lateral views: 26, *S. decui*; 27, *S. dumitrescoae*; 28, *S. brevipatellatus*; 29, *S. longipalpus*; 30, *S. cousinensis*; 31, *S. primibiconourus*; 32, *S. gladiger*; 33, *S. desecheo*.

Schizomus cousinensis, new species

(Figs. 8, 13, 30, 68)

Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots indistinct. Anterior sternum with 11 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with slightly rounded posterodorsal process. Vestigial stigmata darker than sterna. Flagellum spade shaped, with a pair of subdistal depressions flanked by two small, but well-defined elevations. Pedipalpal trochanter not produced distally, but it and other palpal segments elongate, but without armature. Tarsal-basitarsal spurs about 1/6, claw about 1/4 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 35-7-8-6-8-8-18. Other leg measurements given in Table 4.

Female. Carapace with three pairs of dorsal setae. Flagellum with four sections. Pedipalps not elongate. Lateral spermathecae twice length of medians. Laterals terminate in large, highly sclerotized bulbs.

Type data.—Holotype male and allotype female taken in Cousin's Cove Cave No. 1, Cousin's Cove, Hanover Parish, Jamaica, 31 August 1974 (S. Peck) (AMNH). Paratype male and female with same data (TTU).

Comparisons.—See under *S. primibiconourus*.

Distribution.—Known only from the type locality.

Etymology.—The specific name is an adjectival form taken from Cousin's Cove Cave, meaning belonging to.

Remarks.—See under *S. primibiconourus*.

Variations.—The holotype possesses extremely long pedipalps, but those of the male paratype are short and very much like those of the allotype and female paratype.

Schizomus primibiconourus, new species

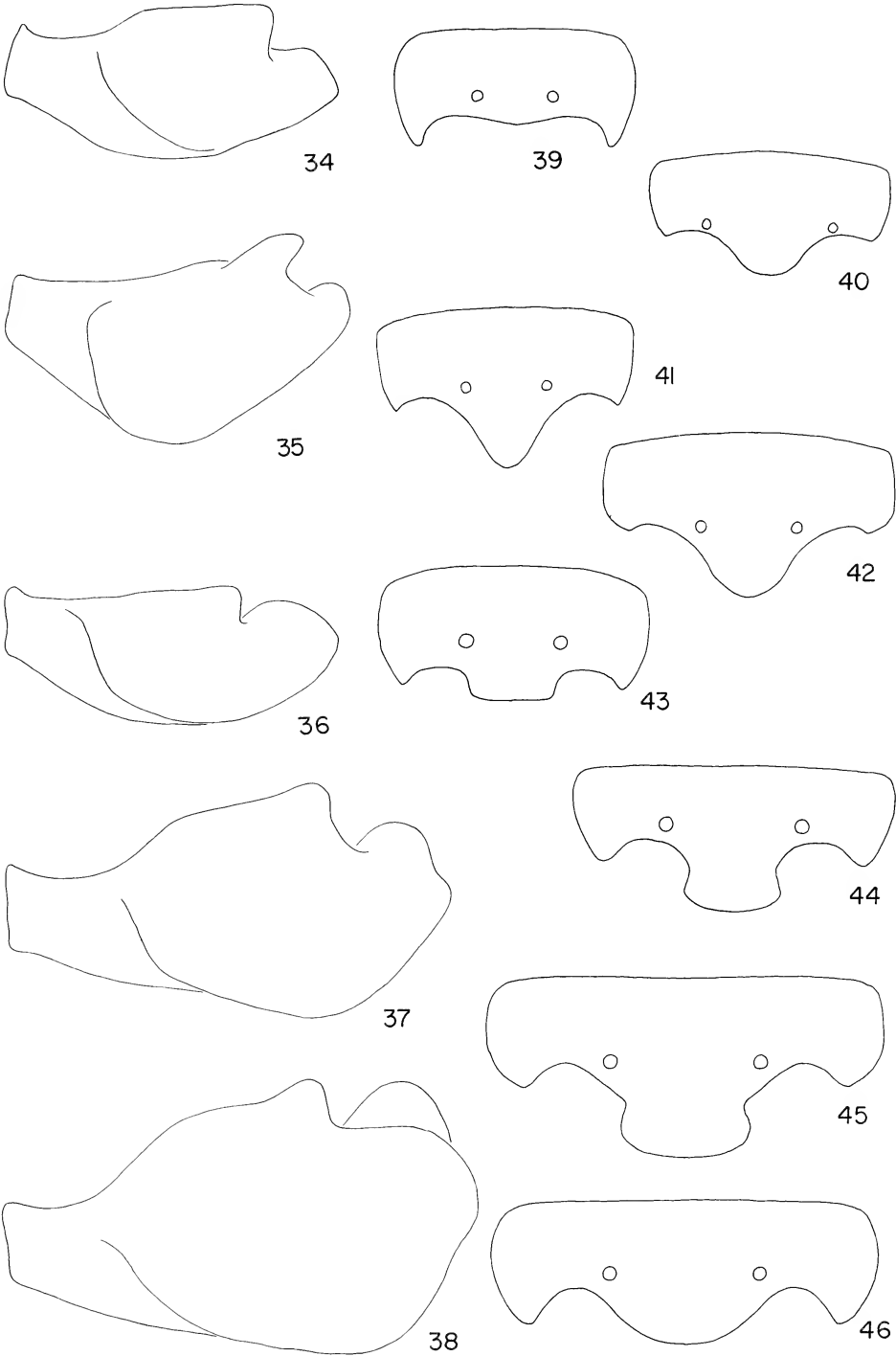
(Figs. 8, 14, 31, 39, 52)

Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots indistinct. Anterior sternum with 11 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with slight emargination of posterodorsal process. Vestigial stigmata darker than sterna. Flagellum spade shaped, with distal depression flanked by two small, but well-developed elevations. Pedipalpal trochanter slightly produced apically, not elongate, other segments slightly elongate, but without armature. Tarsal-basitarsal spurs about 1/5, claw about 1/3 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 43-7-8-11-9-10-19. Other leg segment measurements given in Table 4.

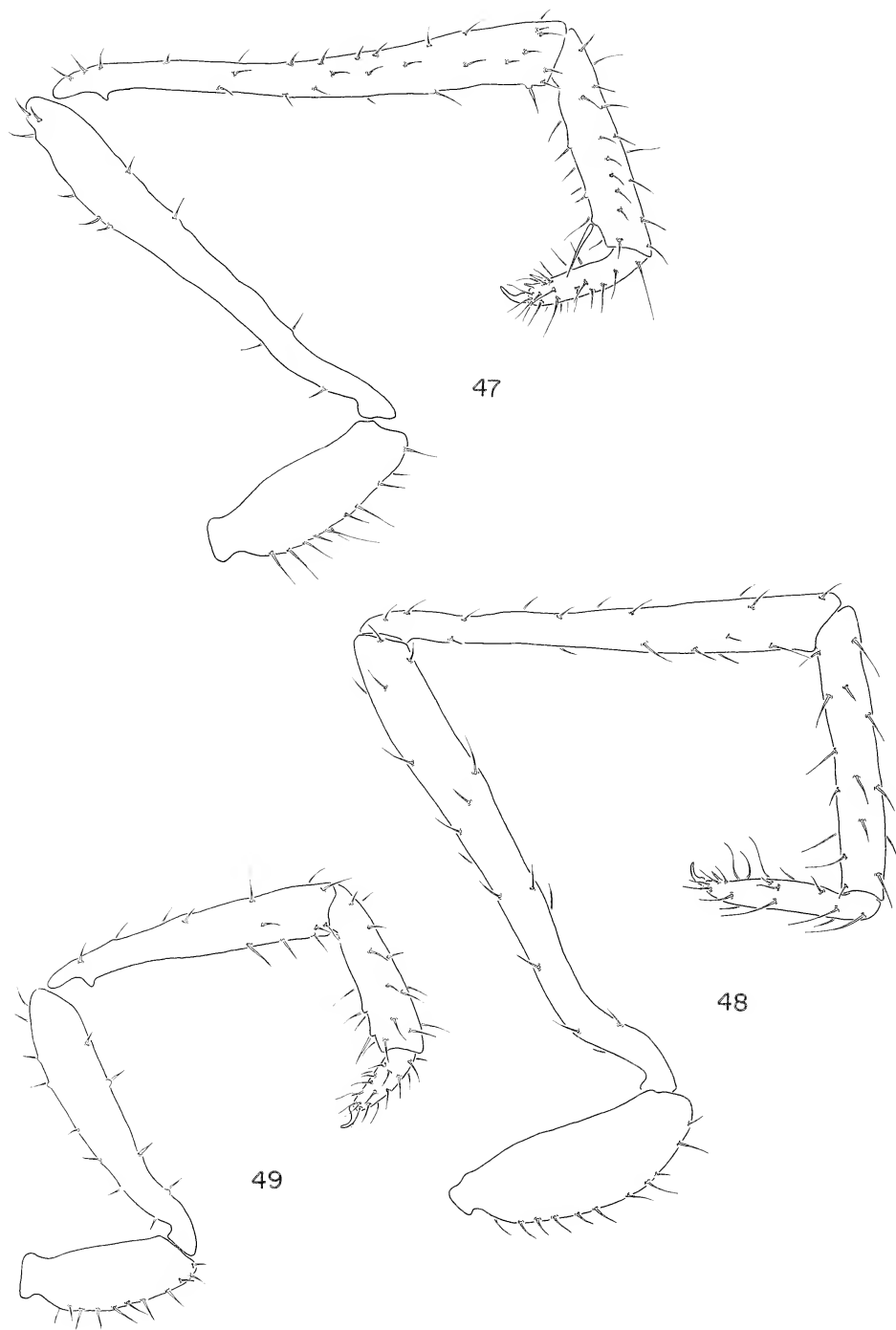
Female unknown.

Type data.—Holotype male taken in Oxford Cave, Auchtembeddie, Manchester Parish, Jamaica, 4-8 April 1968 (S. Peck and A. Fiske) (AMNH). Paratype male taken with the holotype (TTU). Paratype male taken in St. Claire Cave, 1.5 mi. SW Ewarton, St. Catherine Parish, Jamaica, 7 April 1968 (S. Peck and A. Fiske) (AMNH).

Comparisons.—This species may most readily be distinguished from its closest relative, *S. cousinensis*, by the shape of the male flagellum. *S. primibiconourus* has a single flagellar depression, whereas *S. cousinensis* has a pair of depressions. The development of the elevations lateral to the depressions distinguishes *S. primibiconourus* from *S. decui* and *S. dumitrescoae*.



Figs. 34-46.—Parts of male schizomids of the *dumitrescoae* group: 34-38, lateral views of flagella: 34, *S. monensis*; 35, *S. biconourus*; 36, *S. insignis*; 37, *S. peckorum*; 38, *S. viridis*; 39-46, dorsal views of posterodorsal abdominal process: 39, *S. primibiconourus*; 40, *S. gladiger*; 41, 42, *S. biconourus*; 43, *S. insignis*; 44, *S. peckorum* 45, 46, *S. viridis*.



Figs. 47-49.—Lateral views of male right pedipalp of the *dumitrescoae* group: 47, *S. decui*; 48, *S. insignis*; 49, *S. dumitrescoae*.

Distribution.—This species is known only from Oxford Cave, Manchester Parish, and St. Claire Cave, St. Catherine Parish, Jamaica.

Etymology.—The specific name is from the Latin *primi-* meaning first, *bi* meaning two, the Greek *cono-* meaning cone and *urus* meaning tail. This name describes the primitive condition of the pair of cone-shaped elevations on the flagellum of the male.

Remarks.—While this species and *S. cousinensis* are cladistically closer to *S. longipalpus* and *S. brevipatellatus* they more strongly resemble members of the *dumitrescoae* complex. This is accounted for by the remarkable variation in size and pedipalpal characters in *S. longipalpus* and *S. brevipatellatus*.

The middle pair of dorsal carapacial setae are apparently in a transition state in *S. primibiconourus*. Most species in the *dumitrescoae* group show a reduction in size of this pair.

Variation.—The holotype has a very small seta present on the right side where the middle pair of dorsal carapacial setae occur in other species. A paratype has one on the left side.

Schizomus longipalpus, new species

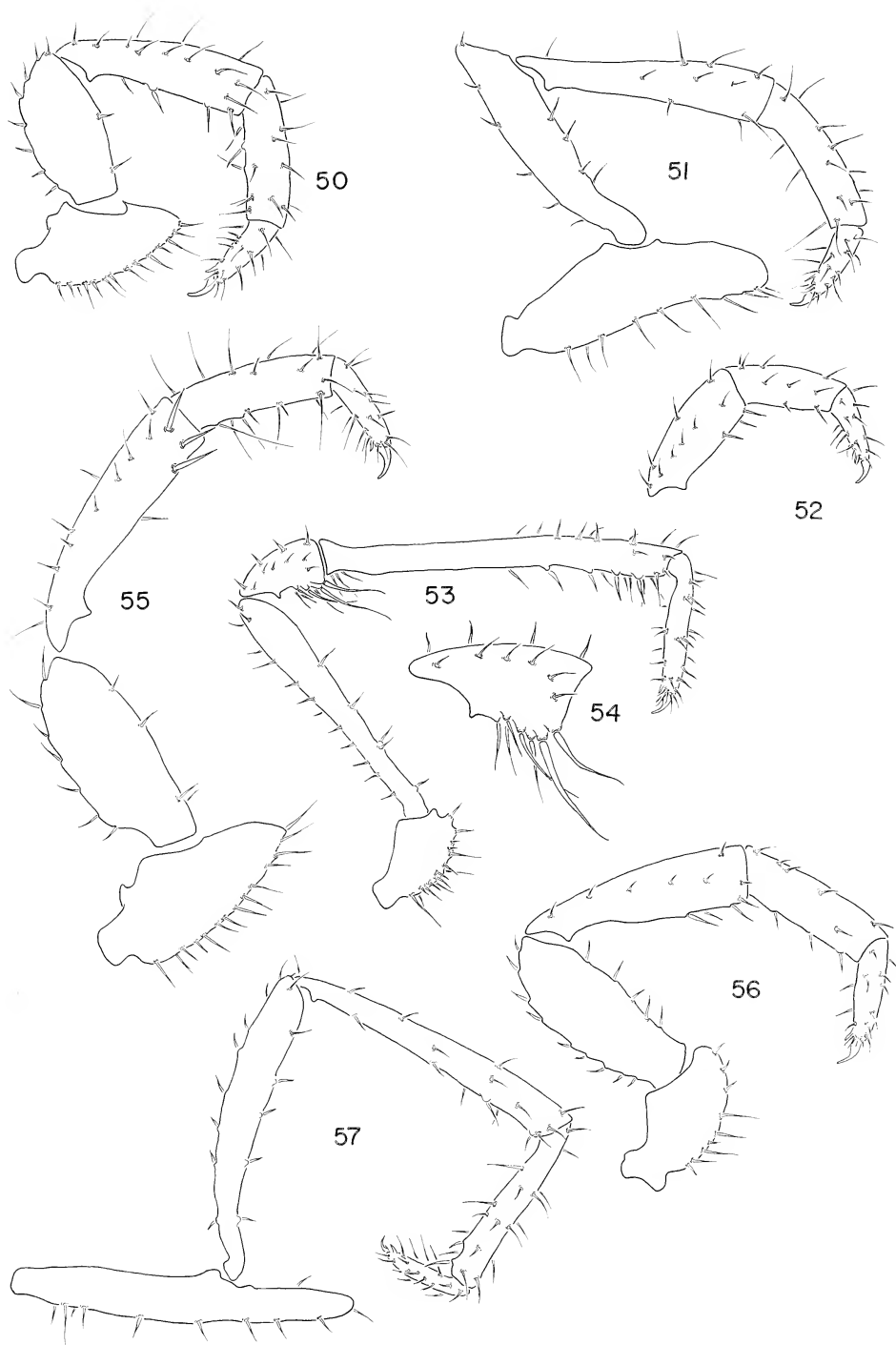
(Figs. 8, 12, 29, 57)

Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots vaguely triangular, irregular, but with distinct borders. Anterior sternum with 13 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with slight development of posterodorsal process. Vestigial stigmata darker than sterna. Flagellum spade shaped, with distomedian depression flanked basolaterally by distinct elevations. Pedipalpal trochanter extremely long and extremely produced distally. Other segments elongate, but unarmed, tibia with a large seta apposable to tarsus-basitarsus. Tarsal-basitarsal spurs about 1/10, claw about 1/4 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 59-10-13-12-13-13-24. Other leg segment measurements given in Table 4.

Female unknown.

Type data.—Holotype male taken at La Vestite, Haiti (6-7000 ft.), 23 September 1916 (Darlington); two paratype males taken at Furey, Haiti, during 1912-1913 (W. M. Mann). All specimens in MCZ.

Comparisons.—*S. longipalpus* is similar in the development of the male pedipalps to other species of the group, except in the extreme elongation of the trochanter, both proximally and distally. Its closest relatives are *S. primibiconourus* and *S. brevipatellatus*. *S. longipalpus* is much larger than *S. primibiconourus*, which also has only slightly elongated palpal segments and a better-developed median flagellar pit, but smaller lateral elevations. *S. brevipatellatus* is somewhat larger than *S. longipalpus* and the flagellum lacks the median pit. The extreme elongation of the pedipalps in the latter two species are probably not homologous developments. The trochanter of *S. longipalpus* is extremely long, but the other segments are not out of the ordinary for the group. The elongation of the pedipalps in *S. brevipatellatus* is achieved by attenuation of the femur and tibia, with the patella being extremely short. The shape of the pedipalps of *S. longipalpus* is very similar to that of *S. digitiger* Dumitresco from Cuba. The shape of the male flagella is also very similar in these two species. They may, however, be readily separated by the presence of two pairs of dorsal carapacial setae in *S. longipalpus* as opposed to three pairs in *S. digitiger*.



Figs. 50-57.—Lateral views of male right pedipalp of the *dumitrescoae* group: 50, *S. biconourus*; 51, *S. gladiger*; 52, *S. primibiconourus*, trochanter and femur omitted; 53, *S. brevipatellatus*; 54, *S. brevipatellatus*, patella only; 55, *S. biconourus*; 56, *S. desecheo*; 57, *S. longipalpus*.

Distribution.—This species is known only from La Vestite and Furey, Haiti.

Etymology.—The specific name comes from the Latin *longi*- meaning long, and palp.

Remarks.—As in *S. brevipatellatus* the remarkable development of the pedipalps may be related to some unusual food source. The great extension of the trochanter in effect sets the apposable parts of the pedipalps some distance from the body proper.

Schizomus brevipatellatus, new species

(Figs. 8, 11, 28, 53-54)

Description.—Male. Color brownish. Carapace with two pairs of dorsal and two apical setae. Eyespots present, but indistinct. Anterior sternum with 13 bifid setae. Abdominal tergum I with two setae, tergum II with four setae, terga III-VI with two setae, terga VII-IX with six setae, segment XII with slight development of posterodorsal process. Vestigial stigmata much darker than sterna. Flagellum lanceolate, slightly dorsally compressed, with a median swelling flanked by lateral pits. Pedipalpal trochanter slightly produced distally, but short; patella short; other segments extremely long, but unarmed. Tarsal-basitarsal spurs about 1/10, claw about 1/5 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 55-9-11-11-14-14-30. Other leg measurements given in Table 5.

Female unknown.

Type data.—Holotype male taken at Cape Haitien, Haiti, January 1913 (W. M. Mann) (MCZ).

Comparisons.—See under *S. longipalpus*.

Distribution.—Known only from the type locality.

Etymology.—The specific name comes from the Latin *brevi*- meaning short, and patella.

Remarks.—The form of the pedipalps is unique among the schizomids. The patella is extremely shortened, and apparently the joint connecting it with the tibia is inflexible. This unique structure probably reflects a novel function of the pedipalp, at least in so far as the apposition of articles. It may be that they serve to allow the males of this species to utilize a food source which is necessarily held away from the body, such as ants or other relatively defensive arthropods.

The flagellum of *S. brevipatellatus* departs greatly from those of the remainder of the group. While this species is similar in other respects to *S. longipalpus* it is probable that the highly modified pedipalps occurred independently in the two species, since the elongation is accomplished in radically different ways in the two species.

Schizomus gladiger Dumitresco

(Figs. 8, 15, 32, 40, 51, 66)

Schizomus gladiger Dumitresco, 1977:147, 150, 153-155, 157, fig. 6.

Description.—Male. Color greenish. Carapace with three pairs of evenly spaced dorsal and two apical setae. Eyespots round to distinctly triangular, well defined. Anterior sternum with 12 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with rounded posterodorsal process. Vestigial stigmata slightly

darker than sterna. Flagellum triangular, with slight apical depression flanked basolaterally and distally by elevations. Pedipalpal trochanter greatly enlarged and produced distally; femur elongate and produced beyond insertion of patella; patella, tibia, and tarsus-basitarsus elongate. Tarsal-basitarsal spurs about $1/8$, claw about $1/3$ length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 30-6-6-6-7-8-19. Other leg segment measurements given in Table 5.

Female. No posterodorsal abdominal process. Flagellum with four articles. Pedipalps not elongate. Lateral spermathecae about twice as long as medians, both with terminal sclerotized bulbs.

Type locality.—Cueva de Banega, vallée de la rivière Río Mogote, á 2 km de la localit   Matias, Provincia de Oriente, Cuba.

Specimens examined.—Two males, two females, and one immature taken at El Marra, Santiago, Cuba, 22 May 1972 (Luis F. de Armas) (IZACC).

Comparisons.—Although this species is most similar in several respects to *S. desecheo* and *S. monensis*, the median flagellar depression is better developed than in the latter two species. The development of the femur of the male pedipalp is unique in being produced beyond its insertion with the patella. *S. gladiger* is distinguished from the males of other Cuban species by the reduction of the median apical depression. This depression is well developed in *S. decui* and *S. biconourus*. Males of *S. rowlandi* Dumitresco and *S. orghidani* Dumitresco apparently lack both the depression and the dorsal elevations.

Distribution.—Known only from Cueva de Banega and El Marra, Cuba.

Remarks.—The articulation of the femur-patellar joint of the pedipalp in male schizomids is probably usually flexible through nearly 180° . The modification of this joint in *S. gladiger* is such that flexure much past a right angle is impossible. Although we have not seen the type specimen of *S. gladiger* the illustrations by Dumitresco (1977) and the geographic proximity of the two collections leave little doubt but that the specimens examined belong to this species.

Variation.—The eyespots of this species may vary from round to triangular. So few specimens are available, however, that the typical condition, if one exists, cannot be ascertained.

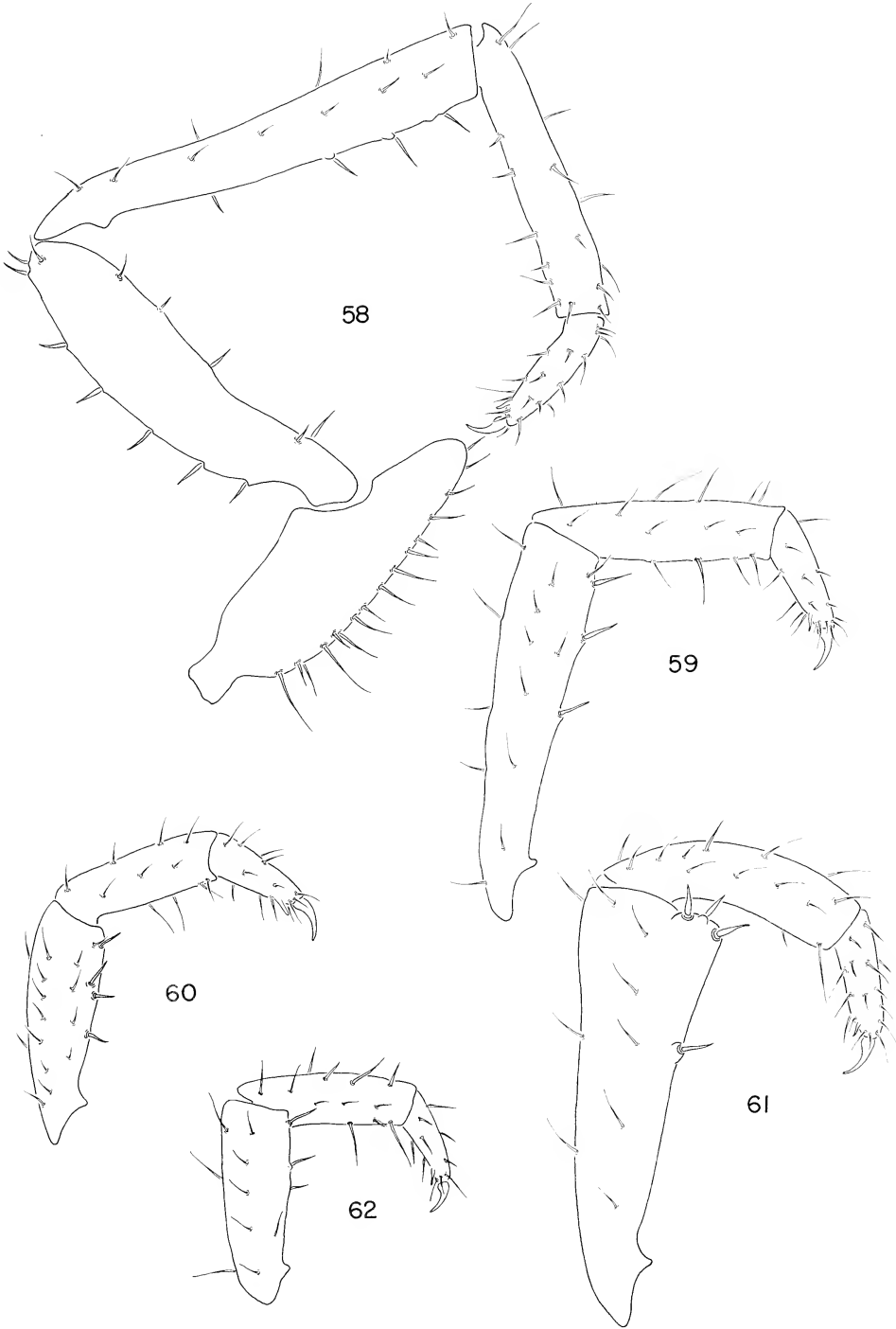
Schizomus monensis, new species

(Figs. 8, 17, 34, 67)

Description.—Male. Color greenish. Carapace with three pairs of dorsal and two apical setae. Eyespots indistinct. Anterior sternum with 11 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, truncate posterodorsal process. Vestigial stigmata darker than sterna. Flagellum spade shaped, thick, with two mediolateral and distal vague elevations, median pit vague or absent. Pedipalpal trochanter produced distally; no segments elongate. Tarsal-basitarsal spurs about $1/6$, claw about $1/3$ length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 37-6-7-7-8-10-19. Other leg segment measurements given in Table 5.

Female. Flagellum with four articles. Lateral spermathecae about one and one-half times as long as medians, laterals terminate in large sclerotized blubs.

Type data.—Holotype male and allotype female taken in Cueva del Agua, Mona Island, Puerto Rico, 3 June 1974 (S. Peck); paratype male, four females, and one immature



Figs. 58-62.—Male right pedipalp of the *dumitrescoae* group: 58-60, lateral views of *S. viridis*; 61, mesal view of *S. viridis*; 62, lateral view of *S. peckorum*.

taken in Cueva Dona Gena, Mona Island, 5 June 1974 (S. Peck); paratype female taken in Cueva Negro, Mona Island, 3 June 1974 (S. Peck). All specimens deposited in the AMNH.

Comparisons.—Males of this species can be distinguished from those of its closest relative, *S. desecheo*, by the much thicker flagellum and the less distinct eyespots. The middle pair of dorsal carapacial setae are smaller in *S. monensis* than in *S. desecheo*. Otherwise the species are very similar. For additional comparisons refer to *S. gladiger*.

Distribution.—This species is known from three caves on Mona Island, Puerto Rico.

Etymology.—The specific name is an adjectival form taken from Mona Island, meaning belonging to.

Variation.—The female allotype has four pairs of dorsal carapacial setae, whereas the other female paratypes have three pairs.

Schizomus desecheo, new species

(Figs. 8, 16, 33, 56)

Description.—Male. Color greenish. Carapace with three pairs of dorsal and two apical setae. Eyespots distinct, angular. Anterior sternum with 10 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, truncate posterodorsal process. Vestigial stigmata distinctly darker than sterna. Flagellum lanceolate, somewhat dorsally compressed with two mediolateral distinct elevations, median pit vague or absent. Pedipalpal trochanter slightly elongate, not produced distally, all other segments only slightly elongate. Tarsal-basitarsal spurs about 1/7, claw about 1/3 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 38-8-8-9-9-10-23. Other leg segment measurements given in Table 5.

Female unknown.

Type data.—Holotype male and paratype immature taken on Desecheo Island, Puerto Rico, 29 March 1961 (J. R. Gorham) (MCZ).

Comparisons.—See under *S. monensis* and *S. gladiger*.

Distribution.—Known only from the type locality.

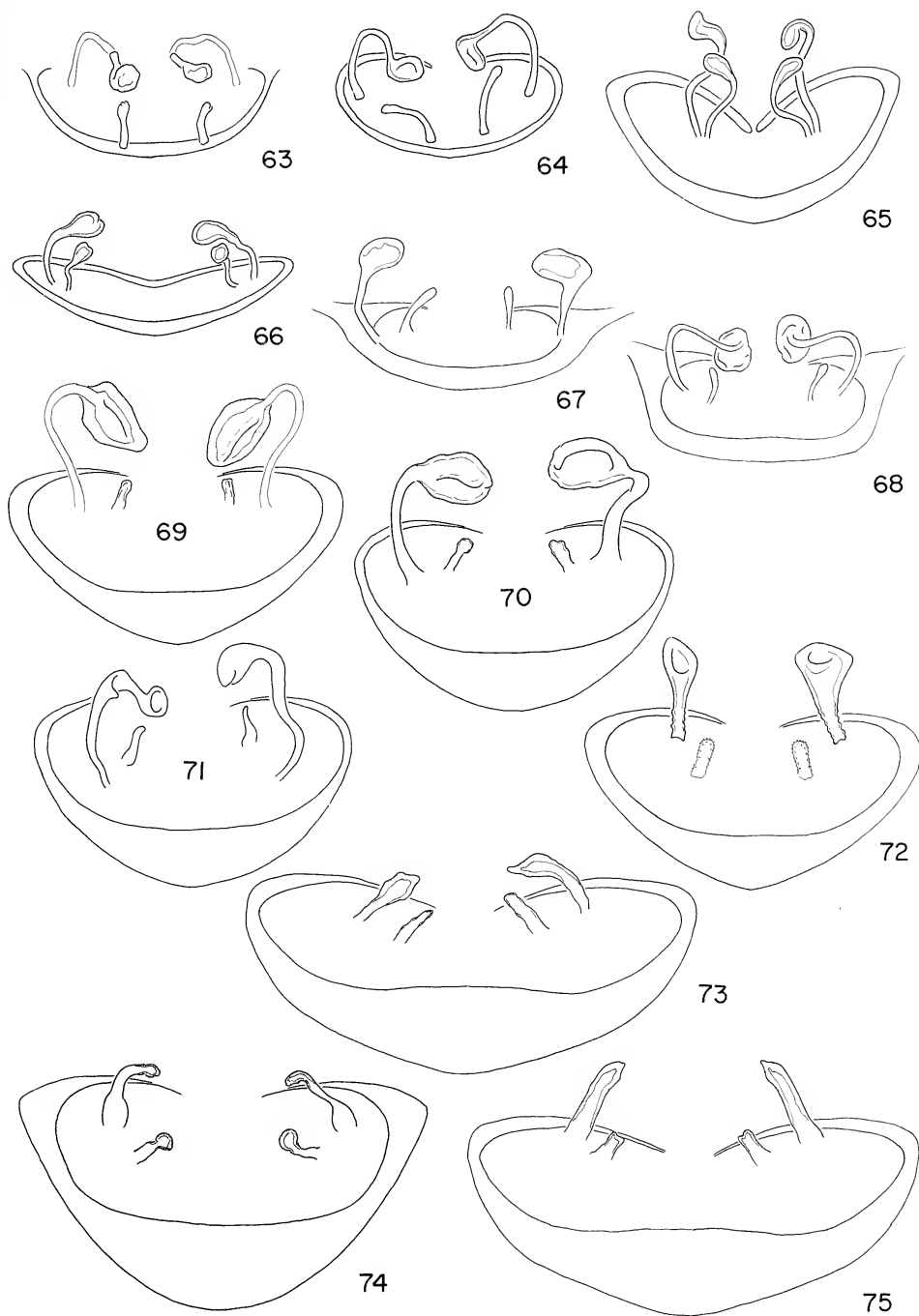
Etymology.—The specific name refers to Desecheo Island and is used as a noun in apposition.

Schizomus biconourus, new species

(Figs. 8, 23, 35, 41-42, 50, 55, 65)

Description.—Male. Color greenish. Carapace with three pairs of dorsal and two apical setae; the dorsals in a tight basal group. Eyespots ovoid. Anterior sternum with 12 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, truncate posterodorsal process. Vestigial stigmata lighter than sterna. Flagellum triangular, with distal depression flanked by pair of well-developed elevations. Pedipalpal trochanter produced distally, armed with a dorsal spur; other segments elongate, but unarmed. Tarsal-basitarsal spurs about 1/8, claw about 1/3 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 34-6-7-8-7-10-21. Other leg segment measurements given in Table 5.

Female. Dorsal carapacial setae not grouped tightly. Flagellum with four articles. Pedipalps not elongate or armed. Lateral spermathecae somewhat longer than the medians, the origins closely situated and lobes slightly overlapping in ventral view. Apex of lateral and median spermathecae expanded into slightly sclerotized bulbs.



Figs. 63-75.—Female spermathecae of the *dumitrescoae* group: 63, 64, *S. dumitrescoae*; 65, *S. biconourus*; 66, *S. gladiger*; 67, *S. monensis*; 68, *S. cousinensis*; 69, 70, *S. peckorum*; 71, *S. insignis*; 72-75, *S. viridis* from various localities: 72, Pedro Great Cave, Clarendon Parish; 73, the type locality; 74, Abby Cave, Manchester Parish; 75, St. Claire Cave, St. Catherine Parish.

Type data.—Holotype male and allotype female taken at Cienfuegos, Soledad, Cuba, 3 September 1972 (Luis F. de Armas) (IZACC); male paratype taken in Soledad, Cuba, 31 July 1933 (J. A. Weber) (MCZ).

Comparisons.—The elevations proximal to the distal flagellar depressions in the males are highly developed in *S. biconourus*. Another Cuban species, *S. negreai* Dumitresco, which we have not seen, seems to possess a lesser, but nonetheless distinct, development of these elevations. Illustrations of *S. negreai* show the flagellum to be much less triangular in shape than in *S. biconourus*. The spermathecae of the two species are apparently very similar.

Distribution.—This species is known only from Soledad, Cuba.

Etymology.—The specific name is from the Latin *bi* meaning two, the Greek *con-* meaning cone and *urus* meaning tail. This name describes the morphology of the flagellum of the male of this species.

Schizomus insignis Hansen
(Figs. 8, 25, 36, 43, 48, 71)

Schizomus insignis Hansen (in Hansen and Sørensen) 1905:11, 26, 39, 47-49, 50, 74; Mello-Leitão 1931:18; Giltay 1935:6; Takashima 1943:93; Remy 1961:506.

Description.—Male. Color greenish. Carapace with three pairs of dorsal and two apical setae. Eyespots oval, but indistinct. Anterior sternum with 11 entire setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, truncate posterodorsal process. Vestigial stigmata almost indistinguishable from sterna. Flagellum spade shaped, with two lateral and a median process separated by a median pit. Pedipalpal trochanter greatly elongate, but not produced distally; other segments elongate and unarmed. Tarsal-basitarsal spurs about 1/10, claw about 1/6 length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following proportions: 36-7-8-8-7-11-18. Other leg segment measurements given in Table 6.

Female. Flagellum with four articles. Pedipalps not elongate. Lateral spermathecae about four times longer than medians. Laterals terminate in highly sclerotized bulbs.

Type data.—Male and immature cotypes taken in Martinique by E. Simon (UZM, examined); female cotype taken in Martinique by E. Simon (MNHN, examined).

Comparisons.—*S. insignis* is about the size of and has similar pedipalps to those of *S. dumitrescoae* and *S. decui*. The latter species are more primitive, however, and lack the greenish color, the pedipalpal trochanter spur, and the median pair of dorsal setae.

Distribution.—Known only from Martinique, Lesser Antilles.

Remarks.—The eyespots are rather hard to see since the types are now quite bleached. Hansen (in Hansen and Sørensen, 1905) describes them as “moderately large, short but broad, whitish.” How they compare to other species of the *dumitrescoae* groups is uncertain.

Schizomus peckorum, new species
(Figs. 8, 24, 37, 44, 62, 69-70)

Description.—Male. Color greenish. Carapace with three pairs of dorsal and two apical setae, the median dorsals very reduced. Eyespots oval, well defined. Anterior sternum

with 13 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, truncate posterodorsal process. Vestigial stigmata darker than sterna. Flagellum nearly globose, with two lateral and one median processes separated by median pit. Pedipalpal trochanter produced distally; other segments slightly elongate, but unarmed. Tarsal-basitarsal spurs about $1/7$, claw about $1/3$ length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 50-8-11-10-11-12-23. Other leg segment measurements given in Table 6.

Female. Flagellum with four articles. Pedipalps not elongate. Lateral spermathecae about five times length of medians, laterals with extreme development of sclerotized bulbs.

Type data.—Holotype male, allotype female, and paratype female taken in Windsor Great Cave, Windsor, 10 mi. S Falmouth, Trelawney Parish, Jamaica, 5 April 1968 (S. Peck and A. Fiske) (AMNH); paratype male and five paratype females taken in Mosley Hall Cave, near Guys Hill, St. Ann Parish, Jamaica, 27 December 1972 (S. and J. Peck) (TTU).

Comparisons.—*S. peckorum* is most similar to *S. viridis* in several respects. *S. peckorum* males, however, have a smaller flagellum, with better-defined elevations. The spermathecae of *S. peckorum* have much larger sclerotized terminal bulbs. In *S. viridis* the laterals have small bulbs and the medians are only slightly shorter.

Distribution.—Known only from two caves in Trelawney and St. Ann Parishes, Jamaica.

Etymology.—The specific name is a patronym given for Drs. Stewart and Jarmila Peck, collectors of this species.

Schizomus viridis, new species

(Figs. 8, 18-22, 38, 45-46, 58-61, 72-75)

Description.—Male. Color green. Carapace with three pairs of dorsal and two apical setae, the median dorsal pair extremely reduced. Eyespots triangular and well defined. Anterior sternum with 13 bifid setae. Abdominal terga I-VII with two setae, terga VIII-IX with four setae, segment XII with well-developed, round to truncate posterodorsal process. Vestigial stigmata darker than sterna. Flagellum globose, with two lateral and a median poorly-defined process, median pit present, but vague. Pedipalpal trochanter produced distally, the other segments elongate. Tarsal-basitarsal spurs about $1/7$, claw about $1/3$ length of tarsus-basitarsus. Tarsal-basitarsal segments of leg I of the following approximate proportions: 52-8-11-11-10-12-23. Other leg segment measurements given in Table 6.

Female. Flagellum with four articles. Pedipalps not elongate. Lateral spermathecae two or three times longer than medians, the apex of the medians and laterals with small sclerotized bulbs.

Type data.—Holotype male, allotype female, and paratype male, three females, and six immatures taken in Abbey Cave, 2.5 mi. SW Mandeville, Manchester Parish, Jamaica, 24 December 1973 (S. and J. Peck) (AMNH).

Comparisons.—See under *S. peckorum*.

Distribution.—This species is known from St. Ann, St. Catherine, St. Claire, Clarendon, St. Elizabeth, Manchester, and Trelawney Parishes, Jamaica.

Etymology.—The specific name is from the Latin *viridi-* meaning green.

Remarks.—This species is the most highly advanced *dumitrescoae* group member and the most widely distributed species in Jamaica. It inhabits both cave and epigean habitats and has been collected with *S. portoricensis* (Chamberlin), *S. primibiconourus*, and an underscribed species of *Schizomus*.

Variation.—There seems to be substantial geographic variation in the male flagellum and pedipalps and in the female spermathecae of this species, and this species may include several geographical isolates.

Additional records.—Jamaica: St. Ann Parish; Chesterfield Cave, 27 March 1973 (R. Norton, R. Zimmerman), 1 male (TTU), Ken Connell Hole, 8 mi. S Claremont, 19 August 1974 (S. Peck), 1 female, 5 immatures (MCZ), Douglas Castle, Brambribo Cave, 18 August 1974 (S. Peck), 1 male, 1 immature male (AMNH), Douglas Castle, Falling Cave, 18 August 1974 (S. Peck), 1 male, 2 immatures (TTU), Hutchinson Hole Cave, 27 March 1973 (R. Norton, R. Zimmerman), 3 males, 1 female, 5 immatures (AMNH), Thatchfield Light Hole, 28 March 1973 (R. Norton, R. Zimmerman), 7 males, 6 females, 5 immatures (TTU), Thatchfield great Cave, 24 October 1973 (R. Norton), 2 females (AMNH), Cave River Cave, Aenon Town, 2 September 1974 (S. Peck), 4 males, 2 females, 12 immatures (TTU), Mt. Plenty Cave, Goshen, 20 August 1974 (S. Peck), 1 male, 4 females, 4 immatures (AMNH), Goshen (1500 ft.), 25 December 1973 (S. and J. Peck), 1 female (AMNH); St. Catherine Parish; Swansea Cave, 4 November 1973 (R. Norton), 3 males, 1 female, 2 immatures (TTU), St. Claire Cave, 1.5 mi. SW Ewarton, 7 April 1968 (S. Peck, A. Fiske), 1 male, 7 females, 5 immatures (TTU); Clarendon Parish; Jackson Bay Cave, 15 August 1974 (S. Peck), 1 female, 1 immature (AMNH), Jackson Bay Cave, Jackson Bay, 2 August 1974 (S. Peck), 1 male, 1 female, 1 immature (AMNH), Pedro Great Cave, Pedro River, 17 August 1974 (S. Peck), 4 males, 3 females, 2 immatures (MCZ), Pedro Great Cave, Pedro River, 20 December 1972 (S. and J. Peck), 3 males, 1 female, 1 immature (AMNH); St. Elizabeth Parish; Wallingford Sink Cave, Wallingford, 27 August 1974 (S. Peck), 1 male, 3 females, 1 immature (TTU), Peru Cave, 5 mi. ENE Santa Cruz, 23 December 1972 (S. and J. Peck), 1 female (TTU); Trelawney Parish; Drip Cave, 1.5 mi. SSE Stewart Town, 2 April 1968 (S. Peck, A. Fiske), 3 males, 1 female, 2 immatures (MCZ), Windsor Great Cave, 29 March 1973 (R. Norton), 1 immature (AMNH).

ACKNOWLEDGMENTS

We express our particular appreciation to Dr. Robert W. Mitchell for his assistance during the entire course of this study. We are also very grateful to Dr. Stewart B. Peck for allowing us to study his extensive collection of schizomids from the Caribbean region. The following curators made material available from their respective institutions: Dr. J. A. L. Cooke, American Museum of Natural History, New York (AMNH); Dr. Luis F. de Armas, Instituto de Zoología, Academia de Ciencias, La Habana, Cuba (IZACC); Dr. W. J. Gertsch (AMNH); Dr. H. W. Levi, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Dr. Robert W. Mitchell, Texas Tech University, Lubbock, Texas (TTU); Dr. Norman I. Platnick (AMNH); Dr. R. X. Schick, California Academy of Sciences, San Francisco, California (CAS); Prof. S. L. Tuxen, Universitetets Zoologiske Museum, Copenhagen, Denmark (UZMK); and Prof. M. Vachon, Musée National d'Histoire Naturelle, Paris (MNHN). Dr. Oscar F. Francke and Mr. Frederick W. Wagner critically read the manuscript and made many helpful suggestions.

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TESTS FOR OLFACTORY COMMUNICATION IN FOUR SPECIES OF WOLF SPIDERS (ARANEAE, LYCOSIDAE)¹

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ABSTRACT

Females of four species of wolf spiders were examined for the presence of an airborne pheromone(s): *Schizocosa saltatrix*, *S. ocreata*, *Lycosa rabida*, *L. punctulata*. Two types of olfactometers were employed: an open arena-type olfactometer and a Y-olfactometer. Data indicate that male *S. saltatrix* exhibit an orthokinetic response to distant conspecific females. Male *S. ocreata* may exhibit a taxis response to distant females. Neither *Lycosa* species exhibits a change in behavior in response to a hidden female.

INTRODUCTION

Contact and olfactory pheromones are important in intraspecific communication in arthropods (Shorey 1976). Among the Araneae, contact sex pheromones associated with the female integument and dragline elicit sexual behavior in conspecific males (Dijkstra 1976, Dondale and Hegdekar 1973, Hegdekar and Dondale 1969, Kaston 1936, Rovner 1968, Tietjen 1977). Airborne sex pheromones are known for two families of the Araneae. In salticids, distance chemoreception is a secondary releaser of courtship behavior, while vision is the primary releaser (Crane 1949). An airborne pheromone aids male orientation to female webs in some species of the Araneidae (Blanke 1973, 1975a, 1975b, Enders unpubl. data).

Hegdekar and Dondale (1969), working with four species of lycosids, found no evidence of an olfactory pheromone. Other researchers have suggested that some male lycosids may employ olfactory orientation to detect and locate conspecific females at a distance, but no experimental evidence was provided (Bristowe and Locket 1926, Dijkstra 1976, Vlijm et al. 1963).

¹ This study was supported by National Science Foundation Grant BNS 76-15009 to J. S. Rovner.

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In the present study male lycosid spiders were used to assay for the possible presence of an airborne component of the female sex pheromone. *Schizocosa saltatrix* (Hentz) and *Schizocosa ocreata* (Hentz) exhibited evidence of chemical signaling at a distance while *Lycosa rabida* Walckenaer and *Lycosa punctulata* Hentz did not.

METHODS

Four species were examined: *Schizocosa saltatrix*, *S. ocreata*, *Lycosa rabida* and *L. punctulata*. *S. ocreata* has been reported previously as *S. crassipes* (Walckenaer) (Dondale and Redner 1978). Animals were collected near Athens, Ohio, USA, during the spring and summer of 1974 through 1976. General methods concerning maintenance and observation of lycosid spiders have been previously described (Tietjen 1977).

I constructed two types of olfactometers. An "arena olfactometer" was designed to determine the response of a test male in an open field to a concealed conspecific. A "Y-olfactometer" was designed to provide a test male with a choice among airstreams which had passed over a concealed conspecific or an empty cage. Both olfactometers were constructed with glass.

The arena olfactometer consisted of a 520 x 600 mm test field marked with 40 x 40 mm squares. An isolation chamber was randomly placed at one of the four corners of the arena. This chamber contained a wire cage which held the stimulus that was presented to the test male in the arena (Fig. 1). Three stimuli were used: a conspecific male or female, or an empty cage. The wire cage containing the stimulus was hung from a glass rod within the isolation chamber to minimize the transmission of vibrational cues from the stimulus animal to the test male. Visual isolation of the stimulus animal and test male was provided by an opaque glass cover with a fine mesh screen in front. A gentle stream of air issuing from a hair dryer was directed through the stimulus cage and into the test arena. The hair dryer was modified by removing all heating elements and baffling that could interfere with the flow of cool air. The air output hose was attached to a series of smaller

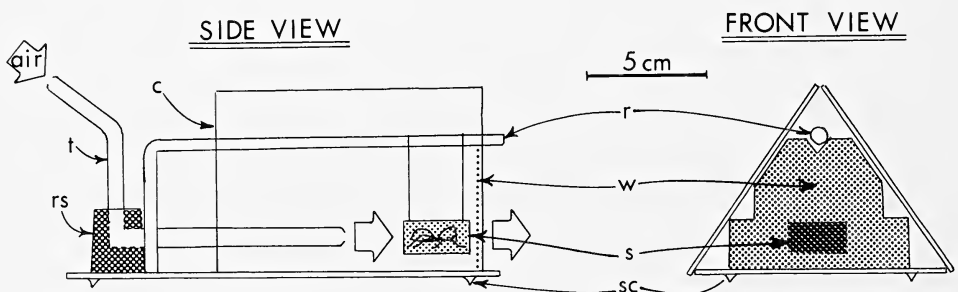


Fig. 1.—Arena olfactometer isolation chamber. Air flow through the metal tubing (t) and over the hidden stimulus (s) is indicated by the large arrows. A bored rubber stopper (rs) supported the metal tubing. Visual isolation between the test male and the stimulus was achieved through the use of an opaque glass construction, a closed back (c), and a fine meshed screen on the open front (w). A glass rod (r) provided support for the stimulus. Mechanical isolation between the test male and stimulus was augmented by silicone rubber supports (sc).

hoses (I.D.=3.0 mm) which provided a back pressure thus reducing the speed and volume of air flow over the stimulus. Each trial was 10 min in duration. At the conclusion of the trial the test male was placed in a cage containing conspecific female silk. If the test male did not show courtship behavior within 5 min, he was considered to be of low sexual tone (Crane 1949), and the trial was not used in the analysis of data. I washed the apparatus between runs with distilled water and attached a clean tissue paper substratum to the floor of the arena.

The Y-olfactometer permitted simultaneous presentation of three airborne stimuli to a test male located in a central area (Fig. 2). Empty stimulus cages, or cages containing a conspecific male or female were positioned at the end of each of the three arms. Vibrational cues from the stimulus animals were minimized by hanging the cages from a rod that had its support in a petri dish filled with sand. This was also shock-mounted by means of silicone rubber supports. Opaque baffles in the arms provided for visual isolation between the test males and the stimuli.

Air flow over the stimulus cages and into the central test arena was generated by heating air in a chimney located above the test arena with a rheostat-controlled ($V=90\text{VAC}$) 200 ohms, 3 watt, wire-wound resistor. Krafft (pers. comm.) used a similar method for generating air flow through a two-arm olfactometer. In preliminary tests, smoke released at the end of each arm indicated that air flow was similar among arms. Air from the three arms showed little mixing until a level of 80-100 mm above the substratum. The entire apparatus was rotated 120° between experimental runs to minimize possible directional bias.

Experimental runs began with a 2-min acclimation period for the test male. This period also allowed for equilibration of the olfactometer. Each trial was 15 min in duration, during which time the behavior of the test male was recorded at 15-sec intervals. The location of the male's right palp defined his position within the arena. If the male was in the third of the arena in front of the first arm, he was recorded as occupying Field 1, and so forth for the second and third fields. Males could also enter the first 45 mm of an arm and were then recorded as having a position within that arm. The direction the test male was facing, defined by an imaginary anteriorly directed midline vector, was recorded in degrees. This orientation was recorded to the nearest 30° . The measurement in degrees was referred to, and proceeded counterclockwise from Arm 1 of the olfactometer. Additional behaviors such as courtship, sound-production, threat display and body position were recorded (Kaston 1936, Rovner 1968, 1975, Tietjen unpubl. data).

Following a 15-min trial, the test male was transferred to a cage containing conspecific female silk, and the latency of chemoexploratory and courtship behavior were recorded. Chemoexploratory behavior has been characterized by the male examining the substratum and silk such that the dorsum of the palp contacts the explored surface as the palps move alternately in an anterior direction (Tietjen 1977). Males that did not court within 5 min were considered to be of low sexual tone and their trials were not used in the analyses of data.

Statistical analyses were performed according to the methods of Sokal and Rohlf (1969), Conover (1971) and Batschelet (1965). All means are accompanied by their standard errors unless otherwise indicated.

Male *L. rabida* were confined in an isolation cage containing silk deposited by female *L. rabida* to induce courtship behavior. Measurements were obtained with a General Radio sound level meter (Type 1551-C) and a high-sensitivity vibration pickup (Type

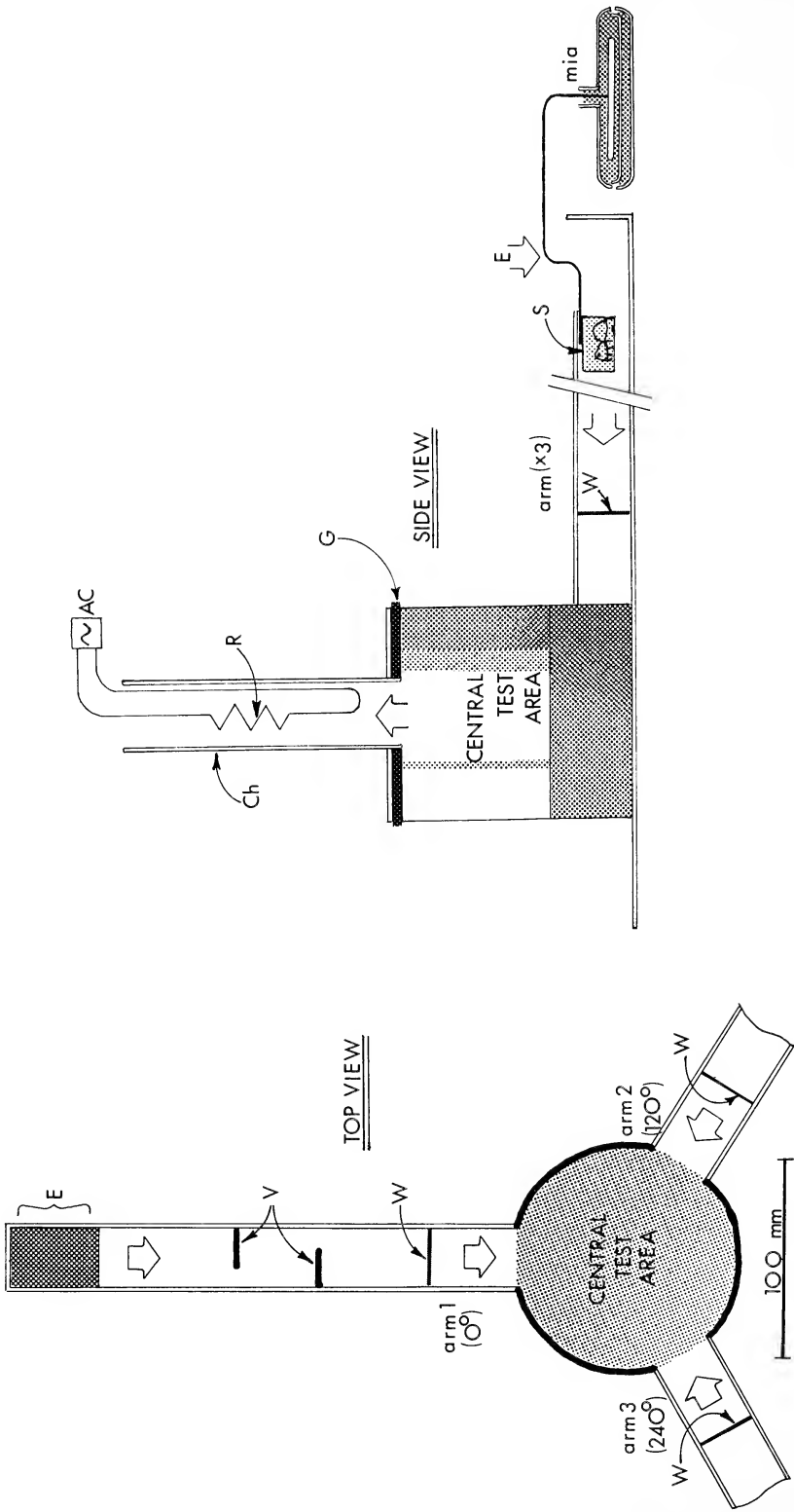


Table 1.—Behavioral responses of male *Schizocosa saltatrix*, *S. ocreata*, *Lycosa rabida* and *L. punctulata* to concealed stimuli in the arena olfactometer. The distance covered was estimated as the number of 40 X 40 mm squares traversed by a test male during a 10 min trial. The center time data provides an estimate of the time a test male spent in the central area of the arena in min. The distance covered and center time data are shown as the $\bar{Y} \pm SE$. The frequencies of courtship (Court Freq.), males entering an isolation chamber (Enter Freq.), males exhibiting sound-production (Sound-prod. Freq), threat display (Threat Freq.) and directed exploratory behavior (DEB Freq.) are shown as the percent of test males exhibiting the indicated behavior. The sample size is shown in parentheses following the concealed stimuli for each species. A T-statistic indicates the value for a Kruskal-Wallis test while a χ^2 statistic indicates the value calculated for a Chi-square test. Significant test values are indicated as follows: *=P<0.05, **=P<0.01.

Species	Distance covered	Center time	Court Freq.	Enter Freq.	Sound-prod. Freq.	Threat Freq.	DEB Freq.
<i>S. saltatrix</i>							
Female (20)	16.2±6.0	4.59±1.0	35.0	15.0	—	—	5.0
Male (20)	46.6±5.7	3.78±0.6	5.0	5.0	—	—	5.0
Empty cage (5)	25.8±9.0	7.04±1.7	0.0	0.0	—	—	20.0
Test	T=14.2*	T=2.6	$X^2=7.4^*$	$X^2=1.8$	—	—	$X^2=1.63$
<i>S. ocreata</i>							
Female (20)	125.9±21.6	3.98±0.8	—	25.0	75.0	—	35.0
Male (20)	129.1±19.1	3.49±0.8	—	10.0	50.0	—	0.0
Empty cage (20)	143.8±19.3	2.06±0.5	—	0.0	60.0	—	5.0
Test	T=0.49	T=2.52	—	$X^2=6.2^*$	$X^2=2.7$	—	$X^2=12.4^{**}$
<i>L. rabida</i>							
Female(20)	76.0±20.6	5.24±0.7	10.0	0.0	60.0	40.0	60.0
Male (20)	90.5±30.8	5.53±0.9	5.0	0.0	35.0	15.0	10.0
Empty cage (20)	58.0±19.7	5.80±0.8	5.0	0.0	50.0	20.0	40.0
Test	T=0.08	T=0.21	$X^2=0.5$	$X^2=0.0$	$X^2=2.5$	$X^2=3.7$	$X^2=10.9^{**}$
<i>L. punctulata</i>							
Female (20)	146.1±37.8	3.61±0.7	0.0	0.0	30.0	45.0	50.0
Male (20)	163.2±45.2	2.67±0.6	5.0	5.0	20.0	40.0	25.0
Empty cage (20)	106.6±19.5	3.36±0.5	0.0	0.0	15.0	50.0	25.0
Test	T=0.14	T=2.01	$X^2=2.1$	$X^2=2.1$	$X^2=1.4$	$X^2=0.4$	$X^2=3.8$

1560-P14) was placed within the area normally occupied by the test male. No increase in vibration levels during male stridulation was noted over the 35-40 decibel background noise. Similar results were obtained when the Y-olfactometer was tested. This indicated that mechanical isolation between the test male and isolated animals is adequate under the extreme condition of male stridulation.

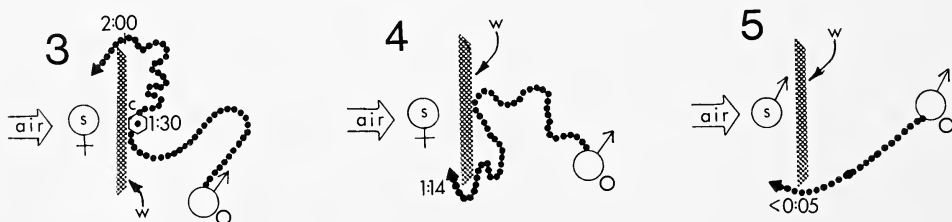


Fig. 2.—Y-olfactometer and mechanical isolation apparatus. A top and side view of the Y-olfactometer is shown. The mechanical isolation apparatus (mia) is shown in its normal position in the side view. Air entered the Y-olfactometer at the end of each arm (E) and flowed over the hidden stimuli (s), as indicated by the open arrows. A gentle air flow was provided by heating air in a chimney (Ch) with a 200 ohm, 3 watt resistor (R). An oil gasket (G) provided an air-tight seal. The male in the central test area was prevented from entering the entire length of the arm by means of wire screens (w). Opaque barriers (V) provided for visual isolation between the hidden stimuli and the test male.

RESULTS

Arena olfactometer.—The number of 40 x 40 mm squares traversed during a 10-min observation period was used to estimate the total distance traveled by a male. Unlike males of the other three species, the distance traveled by male *S. saltatrix* was affected by the concealed stimulus (Table 1). In the presence of a concealed female, male *S. saltatrix* traveled less distance than they did in the presence of a concealed male or clean cage (Mann-Whitney test, $T=65.0$, $p<0.001$; $T=76.0$, $p<0.05$). In the presence of a concealed male, conspecific male *S. saltatrix* covered the same distance as those in the presence of an empty cage (Mann-Whitney test, $T=30.0$, $p>0.05$). No differences were observed in the frequencies of other behaviors under various experimental conditions (Table 1).

Directed exploratory behavior (=DEB) is characterized by males initiating chemo-exploratory behavior while touching the front screen of the isolation chamber. Unlike males of the other three species, male *S. ocreata* exhibited a higher frequency of DEB when in the presence of a concealed female than when in the presence of a concealed male or empty cage ($\chi^2=8.48$, $df=1$, $p<0.001$; $\chi^2=5.63$, $df=1$, $p<0.025$). The frequency of DEB exhibited by males in the presence of hidden males or empty cages did not differ ($\chi^2=1.03$, $df=1$, $p>0.50$). The experimental stimulus affected the proportion of test males entering the isolation chamber (Table 1). Male *S. ocreata* entered more often when females were concealed than when an empty cage was used ($\chi^2=5.71$, $df=1$, $p<0.025$). The number of males entering isolation chambers with concealed females versus concealed males, or an empty cage versus a concealed male, however, did not differ ($\chi^2=1.56$, $df=1$, $p>0.50$; $\chi^2=2.11$, $df=1$, $p>0.50$). The increase in DEB in response to a hidden female suggests that male *S. ocreata* detect hidden female *S. ocreata* at close range via an airborne pheromone. The analyses of the number of male *S. ocreata* entering isolation chambers showed conflicted results. However, it is likely that males entering an isolation chamber holding a concealed female are responding the different cues than males that enter an isolation chamber holding a concealed male, since their approach to a hidden female involved long, sinuous paths; often stopping to initiate chemoexploratory behavior, while males approaching a hidden male took short, straight paths (Figs. 3, 4, 5).



Figs. 3-5.—Sample trails of male *Schizocosa ocreata* in response to a hidden stimulus (s). The test male's trails began at the origin (O) at time 0:00 min. The origin was 10.0 cm or less from the wire screen (w) that covered the front of the isolation chamber (See Fig. 1). 3, chemoexploratory behavior (c) in response to a hidden female; 4, sinuous path traveled by a test male in response to a hidden female; 5, path of a test male in response to a hidden male.

Table 2.—Number of 15-sec intervals male *Schizocosa saltatrix*, *Lycosa rabida* and *L. punctulata* occupied each field or arm of the Y-olfactometer. The tests run for each species are described in the text. The sample size is indicated in parentheses. Those tests with a sample size less than 20 were analyzed with a Chi-square test; those with a sample size equal to or greater than 20 were analyzed with a Kruskal-Wallis test. A significant test is indicated as *=P<0.05.

Species	Test	Field 1	Field 2	Field 3	Arm 1	Arm 2	Arm 3
<i>S. saltatrix</i>	FME (20)	19.9± 7.0	23.3± 6.4	27.8±5.6	10.5±3.5	19.2±8.6	22.4±6.5
<i>L. rabida</i>	FME (20)	21.7± 7.6	28.4± 6.7	28.9±6.3	10.4±3.6	22.8±4.0	23.7±6.2
	EEE (7)	56.0± 2.2	10.7± 5.4	12.0±9.4	0.0	0.0	0.0*
	FFE (6)	47.5±12.5	36.0	24.0	60.0	0.0	0.0
	MME (5)	45.0±11.2	37.7±17.2	3.5±2.5	3.0±1.0	3.0	0.0
<i>L. punctulata</i>	FME (35)	20.2± 2.4	22.0± 4.5	24.9±4.3	16.4±5.4	9.3±3.7	13.5±4.6
	EEE (35)	14.1± 3.6	25.6± 0.1	19.7±4.3	16.2±3.7	9.0±1.8	14.9±3.6
	FFE (15)	20.0± 7.5	30.6± 5.9	26.6±7.4	2.0	6.0	1.0
	MME (35)	24.4± 4.9	22.7± 5.2	16.8±4.0	28.9±5.8	9.2±2.4	14.9±4.6

The frequency of DEB exhibited by male *L. rabida* was affected by the experimental stimulus while other behaviors were not (Table 1). A decrease in the incidence of DEB was observed in response to a concealed male versus a hidden female or clean cage ($\chi^2=10.99$, df=1, $p<0.001$; $\chi^2=4.80$, df=1, $p<0.05$). No difference was observed in the incidence of DEB in response to a hidden female versus a clean cage ($\chi^2=1.60$, df=1, $p>0.80$). This suggests that male *L. rabida* may be repelled by hidden males.

Male *L. punctulata* exhibited no difference in the frequency or latency of any behavior when compared among stimuli (Table 1).

Y-olfactometer.—All species except *S. ocreata* were run in the Y-olfactometer with a female in Arm 1, a male in Arm 2 and an empty cage in Arm 3 (=FME run). Male *S. ocreata* were found to be continuously active and their behavior could not be recorded accurately. Male *L. rabida* and *L. punctulata* were also run with an empty cage in all three arms (=EEE run), females in two arms with empty cage in arm three (=FFE run), and males in two arms with an empty cage in arm three (=MME run).

The number of 15-sec intervals a test male was observed within a field or arm provided an estimate of the time spent within that field or arm. Males of all three species did not spend more time in one field or arm over another for most experimental runs (Table 2). In view of the arena olfactometer data on *S. saltatrix* and *L. rabida* the above results suggest that the pheromone has only a weak behavioral effect and males do not discriminate among airflows in a choice situation. Male *L. rabida*, however, did not enter the arms during EEE runs. No difference was observed in the time spent within each field during *L. rabida* EEE runs ($\chi^2=0.50$, df=2, $p>0.90$). Male *L. rabida* therefore may receive airborne information indicating that a conspecific is nearby.

Circular analyses of data were performed by two methods. As described below, time analysis was dependent on the frequency an orientation was observed, while incidence analysis depended on orientation events. If a test male had an orientation of 120° for 1 min, calculation of the mean vector for time analysis would depend on a frequency of four 15-sec orientations. Incidence analysis would be performed on a frequency of one

Table 3.—Time and incidence analyses of orientation by male *Schizocosa saltatrix*, *Lycosa rabida* and *L. punctulata* in the Y-olfactometer. The tests run for each species are explained in the text. Sample size for each case is indicated as n_i . The polar angle of the mean vector, ρ ; the standard deviation of ρ corrected for a group interval of 30° , s_c ; and the length of ρ on a unit circle, r are indicated for each case. The Smirnov's test statistic, U^2 , is calculated assuming a circular uniform distribution. Significance levels are indicated as $*$ = $P<0.05$, $***$ = $P<0.001$.

	<i>S. saltatrix</i>	<i>L. rabida</i>				<i>L. punctulata</i>			
	FME	FME	EEE	FFE	MME	FME	EEE	FFE	MME
	Time analysis								
n_i	1200	1200	420	360	300	2100	2100	900	2100
ρ	215.9	216.7	350.7	37.4	148.5	15.2	252.9	202.8	341.7
s_c	± 71.9	± 71.5	± 69.9	± 68.7	± 69.9	± 74.1	± 76.9	± 76.0	± 71.4
r	0.21	0.22	0.26	0.28	0.42	0.17	0.10	0.12	0.22
U^2	4.9***	5.7***	2.8***	2.8***	3.7***	6.4***	5.5***	2.4***	10.0***
	Incidence analysis								
n_i	59	56	20	13	22	147	148	48	159
ρ	202.9	194.0	313.1	334.1	103.9	39.4	302.2	5.6	332.2
s_c	± 78.7	± 78.0	± 71.5	± 62.9	± 74.0	± 79.0	± 79.7	± 78.7	± 77.1
r	0.06	0.07	0.22	0.40	0.17	0.05	0.03	0.06	0.09
U^2	0.09	0.11	0.09	0.12	0.06	0.14	0.16	0.06	0.19*

120° orientation event in the above example. Time analysis resulted in a significant deviation from a circular uniform distribution for all runs (Table 3). Statistical analysis and visual examination of the circular graphs indicated a multimodal distribution consonant with the arms of the olfactometer. Since the distribution of EEE runs was also multimodal, this suggests that test males exhibit a positive anemotaxis which is unaffected by the stimulus over which the air had passed. Incidence analysis “factored out” the anemotactic responses and indicated a circular uniform distribution for all tests but *L. punctulata* MME runs (Table 3). Examination of the *L. punctulata* MME circular graph did not indicate an apparent modality, however, and a Smirnow test indicated that the data did not fit a circular normal distribution ($\chi^2=0.364$, $n_i=159$, $p<0.001$). A Raleigh test indicated that the data fit a circular uniform distribution ($z=1.405$, $k=0.0$, $p>0.05$). The absence of an apparent modality and the results of the above tests suggest that the *L. punctulata* MME runs do fit a circular uniform distribution.

DISCUSSION

Shorey (1976) describes two behavioral responses to an airborne pheromone that could bring individuals together: a change in the rate of locomotion (orthokinesis), or a change in orientation (taxis). An orthokinetic response occurs when an animal decreases its rate of locomotion when in the presence of a pheromone. A chemotactic response may be effected through orientation within a concentration gradient of pheromone or by a response to the flow of the medium (i.e., anemotaxis).

Male *S. saltatrix* in the arena olfactometer exhibited a decrease in the rate of locomotion when in the presence of a concealed female. In the Y-olfactometer, however, male *S. saltatrix* did not exhibit a stimulus dependent orientation. Similarly, the stimulus did

not overcome the propensity of males toward a positive thigmotaxis since the time spent in the center of the arena was similar in all arena olfactometer runs. In the Y-olfactometer male *S. saltatrix* did not spend more time in one field than another. The above results suggest that the airborne pheromone acts as a secondary releaser of a component of male sexual behavior or has only a relatively weak behavioral effect and does not direct the male to the female. Female lycosid spiders exhibit low motility during the breeding season while the active males seek them out (Hallander 1967, Hollander 1972, Richter et al. 1971). *S. saltatrix* are found in a leaf-litter habitat (Fitch 1963). Female *S. saltatrix* are found in the refugia formed by the leaves (Cady, pers. comm.) where a pheromone cloud may be expected to build up. Males passing through the cloud would exhibit a decrease in locomotion thus increasing the chance that the male finds the female (or she finds him) through another sensory modality.

Male *S. ocreata* exhibited a qualitative difference in their approach to hidden stimuli (Figs. 3, 4, 5). It is unlikely that a male pheromone could have directed the test male since they ran directly to the isolation chamber in less than 5 sec and no chemo-exploratory behavior was observed. The test male's behavior towards hidden females suggested a taxis response while the response to hidden males suggested visual orientation to the only conspicuous object in the environment (i.e., the isolation chamber). The design of the apparatus made it unlikely that a pheromone concentration gradient could be produced. An airborne pheromone may have increased the rate of turning by the male or may have initiated an anemotaxis response. However, the relatively long time taken during the approach and the periods of no locomotion suggested that the male was searching for the female through vibrational, visual, or contact chemoreceptive cues. The increase in Directed Exploratory Behavior indicated that males were alerted to the presence of the female. As in *S. saltatrix*, male *S. ocreata* were not observed to change the frequency of positive thigmotaxis in response to various stimuli. *S. ocreata* is found in a habitat similar to that of *S. saltatrix* (Fitch 1963). The males are active while the females are inactive and found in refugia formed by the litter (Cady, in prep.). Unlike *S. saltatrix*, male *S. ocreata* would not be expected to slow their rate of locomotion. *S. ocreata* are expected to increase their rate of turning or actively search for the female using other sensory modalities.

Male *L. rabida* and *L. punctulata* exhibited no differential behavioral responses in either olfactometer that could be attributed to the presence of an airborne female pheromone. Male *L. rabida*, however, exhibited a decrease in DEB in the arena olfactometer with a concealed male. This suggests that a male interference strategy which depends on pheromone cues may exist in this species, but further experimentation is necessary.

The difference between genera could have resulted from the different habitat preferences of the *Schizocosa* and *Lycosa* species. Dragline-following behavior has been observed in the *Lycosa* species, while neither *Schizocosa* species has exhibited dragline-following (Tietjen 1977). Both *Lycosa* species are found in grassy fields where they spend much of their time in the foliage (Fitch 1963). An airborne pheromone would be easily dispersed by air currents in such a habitat. Both *Schizocosa* species are found in leaf litter (Fitch 1963). Females hiding beneath the leaves could produce a pheromone cloud that would not be easily dispersed by wind. On the other hand, the moist leaf habitat of the *Schizocosa* species would quickly inactivate the contact pheromone on the female dragline, as suggested by the laboratory studies of Hegdekar (1973), Hegdekar and

Dondale (1969) and Tietjen (1977). The inactivation of contact female pheromone could explain why dragline-following does not occur in the *Schizocosa* species.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. J. S. Rovner for his suggestions and discussions. Anne Tietjen assisted in the preparation and typing of the manuscript.

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IS THE SEX PHEROMONE OF *LYCOSA RABIDA* (ARANEAE: LYCOSIDAE) DEPOSITED ON A SUBSTRATUM?¹

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ABSTRACT

Male *L. rabida* were used to bioassay seven experimental substrata. Latency and frequency of five behaviors were recorded: courtship, chemoexploration, sound-production, puppet-walking and jolting. Some experimental substrata were covered with conspecific male or female silk. Other substrata were those from cages of females that had their spinnerets occluded before living on a substratum. Lepidopteran silk and clean substrata were used as controls. Data indicate that males exhibit a change in behavior only in response to experimental substrata covered with female silk. These results agree with findings based on species studied by Kaston (1936) and Dondale and Hegdekar (1973), but are opposite from results obtained on other species of wolf spiders by Bristowe and Locket (1926) and Richter et al. (1971).

INTRODUCTION

Bioassay experiments have indicated that a sex pheromone is associated with the dragline of female lycosid spiders (Dondale and Hegdekar 1973, Kaston 1936, Rovner 1968). There has been, however, conflicting evidence concerning a sex pheromone deposited by females through their body surface. Dondale and Hegdekar (1973) and Kaston (1936), by sealing the spinnerets of certain lycosids, showed that a pheromone was not released from the integument of the female and deposited on a substratum. On the other hand, Bristowe and Locket (1926), utilizing a similar experimental design, found that male *Tarentula barbipes* Walkenaer were stimulated by substrata over which a female with sealed spinnerets had walked. Richter et al. (1971) incorporated a larger sample size than the other researchers and indicated that, although male *Pardosa amentata* (Clerck) were not induced to court in the absence of female silk, substrata over which females with sealed spinnerets had walked induced searching behavior in conspecific males.

¹ This study was supported by National Science Foundation Grant BNS 76-15009 to J. S. Rovner.

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Table 1.—Behavioral responses of male *Lycosa rabida* to experimental substrata. Refer to the text for an explanation of the experimental substrata. The sample size for each experimental substrate is indicated in parentheses. The frequencies behaviors were observed are shown in percent of males exhibiting the indicated behavior. The latencies for each behavior are indicated in min± SE.

Experimental substrata		Behaviors				
		Courtship	Chemoexploratory	Sound-production	Puppet-walk	Jolting
SS (40)	frequency	25.0	27.5	47.5	2.5	2.5
	latency	4.04±0.6	2.47±0.7	4.68±0.6	0.00	0.87
CS (40)	frequency	25.0	35.0	52.5	5.0	5.0
	latency	5.52±0.8	3.49±0.7	4.93±0.6	1.04±0.8	4.74±0.6
CR (40)	frequency	50.0	75.0	55.0	12.5	0.0
	latency	278±0.4	1.96±0.3	4.53±0.6	3.47±1.5	---
clean (20)	frequency	15.0	30.0	35.0	5.0	10.0
	latency	4.98±1.9	3.66±1.3	5.21±1.0	6.37	7.35±0.4
lep (20)	frequency	5.0	35.0	40.0	15.0	5.0
	latency	6.07	4.62±1.4	6.23±0.9	6.59±1.7	9.87
male (20)	frequency	0.0	60.0	50.0	20.0	0.0
	latency	---	2.02±0.6	4.21±0.7	2.24±1.0	---
female (20)	frequency	72.5	57.5	25.0	2.5	2.5
	latency	4.06±0.6	0.66±0.3	3.62±0.7	2.27	5.00

The present study includes a statistical analysis of the behavior of male *Lycosa rabida* Walkenaer in response to experimental substrata including those of “sealed-spinneret” females. A variety of male responses to experimental substrata were recorded in an attempt to increase the sensitivity of the bioassay. The results indicate that this species is similar to those studied by Kaston (1936) and Dondale and Hegdekar (1973), in which the female sex pheromone is not released from the integument but is associated with the dragline.

METHODS

General methods concerning collection, maintenance and observation of lycosid spiders have been previously described (Tietjen 1977). One hundred and eighty five *L. rabida* were collected during 1975 near Athens, Ohio, USA; 80 of these were males. Female spiders were divided into three groups. Two groups were experimentally altered. “Sealed-spinneret” females (=SS females, N=10) had their spinnerets sealed and immobilized with paraffin (Dondale and Hegdekar 1973). “Covered-spinneret” females (=CS females, N=10) had their spinnerets and anal tubercle covered with a small patch of nylon cloth which was fixed to the abdomen with paraffin. Care was taken to insure that the anal tubercle was not occluded by paraffin for both SS and CS females. The nylon patch was later removed from the CS females as a control to determine the effect of occluding the spinnerets (=CR females, N=10). Experimentally altered females were transferred to clean plastic cages (130 x 70 x 65 mm) and were provided with a filter paper substratum and a cotton-stoppered water vial. Females were not fed during a two-day holding period and, for the SS and CS conditions, cages were examined to insure the absence of silk. Four additional experimental substrata were employed. Clean substrata (=clean) had not been previously occupied by experimental animals. Lepidopteran substrata (=lep) had lepidopteran silk obtained from the cocoon of

Table 2.—Chi-square analysis of male *Lycosa rabida* courtship frequency in response to experimental substrata. Refer to the text for an explanation of the experimental substrata. Significance levels are indicated as follows: *P<0.05; ***P<0.001; ns=not significant. Row frequencies that are less than column frequencies are indicated as “a”; row frequencies greater than column frequencies are indicated as “b”.

	Experimental substrata						
	CR	SS	CS	female	male	lep	clean
CR	—						
SS	*a	—					
CS	*a	ns	—				
female	*b	***b	***b	—			
male	***a	*a	*a	***a	—		
lep	***a	ns	ns	***a	ns	—	
clean	***a	ns	ns	***a	ns	ns	—

Platysamia cecropia Linnaeus on a paper card. Male and female occupied substrata (=male and female) were cage substrata previously occupied by male or female conspecifics respectively for a period of one-two weeks.

Experimental males were selected randomly with the provision that they not be used more than once during a 24-hour period. The latencies (in min) and frequencies of five behaviors exhibited by males in response to the above substrata were recorded during a 10-min trial. Courtship, chemoexploratory behavior and sound-production have been previously described (Rovner 1967, 1968, Tietjen 1977). Puppet-walking (Vlijm et al. 1963) was similar to the threat display described by Rovner (1968), except that the body was often held higher off the substratum such that the palps either did not extend to the substratum or were curled posteriorly. Sound-production usually occurred when the palps touched the substratum. Such instances were recorded only as “Puppet-walking”. “Jolting” is characterized by the body being held high above the substratum with the palps in contact with the substratum. The body is then moved posteriorly with a sudden jerky motion. The first legs may be lifted from the substratum; and jolting is always accompanied by sound-production. Sound-production occurring during jolting was not recorded separately as “sound-production”.

Statistical analyses of data were performed according to the methods of Conover (1971) and Sokal and Rohlf (1969). Means are accompanied by their standard errors.

RESULTS

The frequency and latency of sound-production, puppet-walking and jolting did not differ among experimental substrata (Chi square test, Kruskal-Wallis test, df=6, 0.50<P<0.80; Table 1). This indicates that male *L. rabida* perform these behaviors at a level that is unaffected by the chemical and tactile stimuli provided by conspecific silk.

The frequency of courtship behavior differed among substrata (Chi square test, df=6, P<0.001 ; Table 1). Courtship frequency was analyzed by a Chi square analysis for each pair of substrata (Table 2). Data indicated that female substrata induced a higher level of courtship than all other substrata and CR induced a higher level than all but female substrata. The frequency of courtship was lower on male substrata when compared to lep

Table 3.—Frequency and latency of chemoexploratory behavior by male *Lycosa rabida* in response to experimental substrata. Refer to the text for an explanation of the experimental substrata. The frequency of chemoexploratory behavior was compared among substrata with a Chi-square test (df=1). The latency of chemoexploratory behavior was tested among substrata with a Mann-Whitney test (df=1). Significance levels are indicated as follows: * P<0.05; ** P<0.01; *** P<0.001; ns=not significant. Row frequencies (or latencies) that are less than column frequencies (or latencies) are indicated as “a”; row frequencies (or latencies) greater than column frequencies (or latencies) are indicated as “b”.

		Experimental substrata							Chemoexploratory latency
		CR	SS	CS	female	male	lep	clean	
Chemoexploratory frequency	CR	—	ns	ns	***b	ns	*a	ns	
	SS	***a	—	ns	**b	ns	ns	ns	
	CS	***a	ns	—	***b	ns	ns	ns	
	female	ns	**b	*b	—	**a	**a	*a	
	male	ns	*b	ns	ns	—	ns	ns	
	lep	***a	ns	ns	ns	ns	—	ns	
	clean	***a	ns	ns	*a	ns	ns	—	

and clean. Courtship latency did not differ among experimental substrata (Kruskal-Wallis test, df=5, 0.50<P<0.90).

The frequency and latency of chemoexploratory behavior differed among substrata (Chi square test, Kruskal-Wallis test, df=6, P<0.001; Table 1). The frequency of chemoexploratory behavior exhibited on SS and CS substrata did not differ from lep and clean (Table 3). In addition, the frequency of chemoexploratory behavior in response to SS and CS substrata was lower than on female and CR substrata. The differences found between female and CR substrata can be attributed to the greater amount of silk found on female substrata. The supernormal stimulus provided by the female substrata also explains the observed decrease in the latency of chemoexploratory behavior (Table 3).

DISCUSSION

These data suggest that female *L. rabida* do not deposit a pheromone from their integument onto a substratum. These results indicate that *L. rabida* is similar to the species studied by Kaston (1936) and Dondale and Hegdekar (1973), but are opposite from the results of Bristowe and Locket (1926) and Richter et al. (1971).

Excreta were deposited on all substrata except CS, lep, and clean. SS substrata with excreta did not induce a higher frequency of courtship or chemoexploratory behavior when compared to CS, lep, or clean. This indicates that a pheromone is not associated with the excreta of female *L. rabida*. These results are in agreement with those of Kaston (1936).

The frequency of chemoexploratory behavior did not differ among substrata having silk. Male substrata, however, induced less courtship behavior than either CR or female substrata. This suggests that, although male silk provides cues that induce chemoexploratory behavior, these cues alone are insufficient to induce courtship. Mechanical

cues provided by female draglines have been shown to direct dragline-following behavior in male *L. rabida* (Tietjen 1977). Such tactile cues may also induce chemoexploratory behavior. In addition, silk from male *L. rabida* may have an associated male pheromone that has an inhibiting effect on male courtship, however additional research is necessary.

In a related study (Tietjen, unpubl. data) male *Lycosa punctulata* Hentz exhibited responses to experimental substrata similar to those of *L. rabida* indicating the female sex pheromone is associated with the dragline and not deposited on a substratum from the integument. *L. rabida* and *L. punctulata* are found in field-type vegetation (Kaston 1948) and are expected to produce relatively large quantities of dragline compared to lycosids found in open-ground type vegetation (Richter 1970). If females lay down relatively large quantities of silk with the associated pheromone, the additional deposition of pheromone from the integument on a substratum may be superfluous and energetically expensive.

Pardosa amentata (Clerck) is found in open-ground type vegetation (Vlijm et al. 1963), as is *Tarentula barbipes* (Bristowe and Locket 1926). If the open-ground species lay down relatively less dragline than those found in field-type vegetation (Richter 1970), then the cost of deposition of pheromone from the integument to a substratum may be justified due to the resulting increase in information flow. Both *T. barbipes* and *P. amentata* have been shown to deposit a pheromone from the integument (Bristowe and Locket 1926, Richter et al. 1971). However, *Pardosa lapidicina* (Emerton), *P. milvina* (Hentz), *P. saxatilis* (Hentz), and *Schizocosa crassipes* (Walckenaer) are found in open-ground type vegetation (Fitch 1963, Kaston 1948), but do not exhibit evidence of an integument-deposited pheromone (Dondale and Hegdekar 1973, Kaston 1936).

The optimum habitats of *P. lapidicina* and *P. milvina* are moist areas surrounding a pond or lake (Fitch 1963). *S. crassipes* has been found to exhibit temperature and moisture preferences (Cady, unpubl. data). The pheromone found on the female dragline has been found to be inactivated by water in a variety of lycosids (Dondale and Hegdekar 1973, Tietjen 1977). An integument-deposited pheromone may be precluded in the above species due to similar constraints imposed by microhabitat preferences. The absence of an integument-deposited pheromone in *L. rabida* also may be related to microhabitat preferences.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. J. S. Rovner for his suggestions and discussions. Anne Tietjen assisted in the typing of the manuscript.

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A REVISION OF THE SPIDER GENUS *BARRISCA* (ARANEAE, RHOICININAE)

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ABSTRACT

The male of *Barrisca nannella* is redescribed, the female is described for the first time, and a new species, *B. kochalkai*, is described from northern Colombia and Venezuela.

INTRODUCTION

Among an assortment of Neotropical spiders sent to me for identification recently by H. W. Levi were a male and two females from Colombia belonging to the genus *Barrisca*, established by Chamberlin and Ivie (1936) for a Panamanian species, *B. nannella*. Since females of *Barrisca* were previously unknown, a review of all the available material seemed appropriate, and has turned up a second species from northern Colombia and Venezuela.

The genus was originally placed by Chamberlin and Ivie in the Agelenidae, and considered by them to be closely related to *Tegenaria*. Roth (1964) noted that the irregularly placed tarsal trichobothria and deeply notched trochanters exclude *Barrisca* from the Agelenidae and subsequently (1965) transferred the genus to the Rhoicininae, which, following Exline (1950, 1960), he placed in the family Pisauridae. There seems little doubt that *Barrisca* is closely related to *Rhoicinus*; in both genera the male cymbium is distally elongated and bears a long prolateral spine at its base. Both the composition and the relationships of the Rhoicininae are very uncertain, however. Of the two other genera placed in the subfamily by Exline (1960), *Calacadia* is, as indicated by Lehtinen (1967), a close relative of *Metaltella* (Amaurobiidae), and the two genera provide an excellent example of closely related cribellate and ecribellate forms. The relationships of *Rhoicinaria* are less clear; Homann's (1952, 1961, 1971) arguments against its close relationship to *Rhoicinus* are convincing, but Lehtinen's (1967) placement of the genus in his Altellopsinae (Amaurobiidae) seems unsupported by any shared derived characters. Of *Xingusiella* Mello-Leitão (1940), added to the Rhoicininae by Lehtinen (1967) without examination of any specimens, virtually nothing is known.

The familial placement of *Rhoicinus* and *Barrisca* is even more problematical. Originally placed in the Lycosidae by Simon (1898), the group was transferred to the Agelenidae by Petrunkevitch (1928), to the Pisauridae by Exline (1950), back to the Lycosidae by Homann (1961, 1971), and to the Amaurobiidae by Lehtinen (1967). Since Homann (1971) treated the Pisauridae (and Ctenidae) as subfamilies of Lycosidae, and ranked the Rhoicininae equivalently with them, his proposal is equivalent to raising the Rhoicininae to family level in more conventional classifications. Homann rejected Lehtinen's placement because of the grate-shaped tapetum of the secondary eyes, believed by him to be a synapomorphy uniting the Stiphidiidae, Psechridae, Lycosidae (in his sense), Senoculidae, Oxyopidae, and possibly Zoropsidae and Acanthoctenidae (but not Amaurobiidae). Few, however, of the extremely large number of genera placed in the Amaurobioidea by Lehtinen (1967) and Forster and Wilton (1973) have had their eye morphology examined, and it seems likely that a grate-shaped tapetum may be found to occur in many of the families established by the latter authors. Six characters of rhoiciniines not shared with the Lycosidae were listed by Exline (1950), and all seem to support Lehtinen's suggested amaurobioid relationship instead. However, Forster and Wilton (1973) indicated that the Lycosidae and Pisauridae may themselves be extremely derived members of the Amaurobioidea, which they characterized by the presence of four unbranched tracheal tubes (possibly a plesiomorphic character). I have examined the tracheal system of a juvenile of *Barrisca kochalkai*, new species, and it does conform to that condition. Thus at present the Rhoicininae seem to be best considered Amaurobioidea *incertae sedis*. If the heuristic trend, initiated by Forster and Wilton (1973), of isolating small groups of related amaurobioid genera as families until their interrelationships can be assessed is continued, the rhoiciniines will probably have to be considered a family (they do not fit the diagnoses of any of the families recognized by Forster and Wilton).

I am indebted to H. W. Levi of the Museum of Comparative Zoology (MCZ) and John A. Kochalka (JAK) for the loan, exchange, and gift of specimens, to M. Hubert of the Muséum National d'Histoire Naturelle for loaning the type of *Rhoicinus wapleri*, to J. E. Carico for making available rhoicinine specimens previously loaned to him from the American Museum of Natural History (AMNH), and to M. U. Shadab for providing the illustrations.

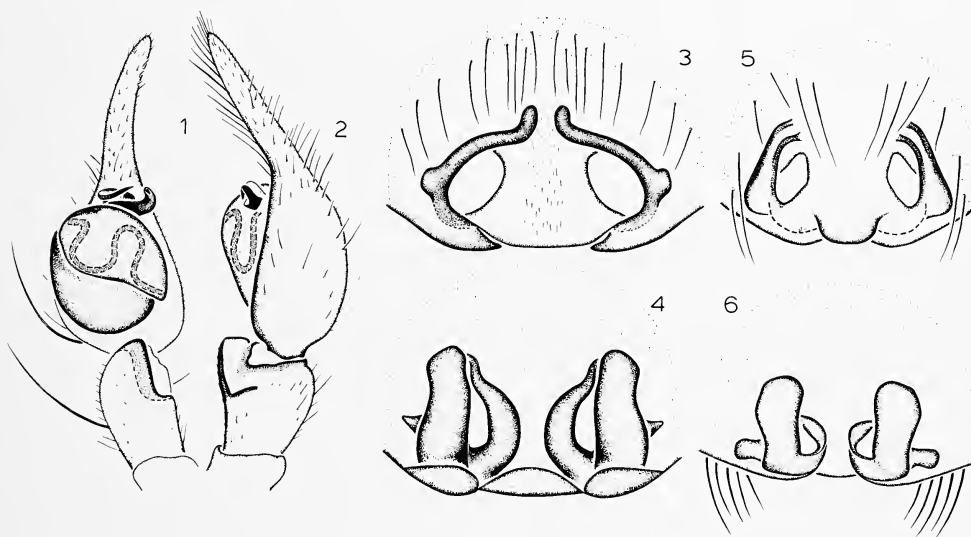
Barrisca Chamberlin and Ivie

Barrisca Chamberlin and Ivie, 1936:15 (type species by original designation *Barrisca nannella* Chamberlin and Ivie).

Diagnosis.—The only genus with which *Barrisca* is likely to be confused is *Rhoicinus*, from which it differs in having the labium no longer than wide rather than considerably longer than wide, the posterior tip of the sternum blunt rather than sharply pointed, the ledge of the male palpal tibial pit situated ventrally rather than retrolaterally, the epigynal openings situated ventrally rather than on a posterior plate, the legs spotted rather than ringed and without the extreme hairiness of *Rhoicinus*, and the first femur much longer than the carapace rather than at most only slightly longer.

Description.—Carapace widest near rear of coxae II, with elongate cephalic region about half of maximum width, moderately elevated, with steep posterior depression; margins dark brown, surrounding pair of submarginal light bands surrounding two broad

dark bands separated by single broad light median band expanded anteriorly to cover most of pars cephalica; surface covered with plumose setae, white and scale-like above light bands; thoracic groove longitudinal. From above, both eye rows recurved; all eyes dark, ringed with black pigment; ratio of eye diameters, anterior lateral: anterior median:posterior lateral:posterior median, 14:11:15:14; anterior medians separated by two-thirds their diameter, by slightly less than their radius from anterior laterals; posterior medians separated by two-thirds their diameter, by their diameter from posterior laterals; median ocular quadrangle much wider in back than in front, about as long as wide in back; clypeal height almost twice the anterior median eye diameter. Chelicerae with three promarginal and three retromarginal teeth; endites rectangular, with anteromedian scopula; labium no longer than wide, laterally notched at base, with rebordered tip; sternum about as long as wide, with blunt extension between coxae IV and invaginated anterior margin, dark brown except for small light yellow spot on midline at about one-fourth its length. Leg formula 4123. Femora heavily spotted, distal leg segments lightly spotted; tibiae, metatarsi, and tarsi with scattered trichobothria; tarsi with three claws, superior claws with several teeth; all trochanters deeply notched. Typical leg spination (only surfaces bearing spines listed): femora: I d1-1-1, p0-2-1, r1-1-1; II d1-1-1, p1-2-1, r1-1-1; III d1-1-1, p1-1-1, r1-1-1; IV d1-1-1, p1-1-1, r0-0-1; patellae: I-IV d1-0-1; tibiae: I, II d1-1-0, p0-1-1, v1r-4-0, r0-0-1; III, IV d1-1-0, p0-1-1, v2-2-2, r0-1-1; metatarsi: I p0-1-2, v2-2-0, r0-1-2; II p1-1-2, v2-2-0, r0-1-2; III, IV p1-1-2, v2-2-0, r1-1-2. Abdomen dark brown with wide orange median longitudinal stripe with two pairs of short lateral oblique extensions at one-third and two-thirds its length, and pair of dark spots at about one-fourth its length; venter light with median dark band and scattered dark spots; anal tubercle divided; anterior spinnerets thick, conical, with short



Figs. 1-6.—1-4: *Barrisca nannella*: 1, left palp, ventral view; 2, left palp, retrolateral view; 3, epigynum, ventral view; 4, epigynum, dorsal view. 5, 6: *Barrisca kochalkai*: 5, epigynum, ventral view; 6, epigynum, dorsal view.

second segment; posterior spinnerets no longer than anteriors, with short second segment; colulus large, oval, preceded by spiracular furrow leading to four unbranched slender tracheae. Male palpal tibia with retrolateral apical excavation bordered by ventral ledge; cymbium elongate, bearing basal prolateral spine. Epigynum with lateral margins, midpiece, and pair of atrial sclerites.

Barrisca nannella Chamberlin and Ivie
Figs. 1-4

Barrisca nannella Chamberlin and Ivie, 1936:15, figs. 28-32 (male holotype from Barro Colorado Island, Canal Zone, Panama, in AMNH, examined). Roth, 1965:291.

Diagnosis.—Females of *B. nannella* may be distinguished from those of *B. kochalkai* by the anteriorly approximate epigynal margins (Fig. 3); males of the former species may be distinguished from those of *Rhoicinus* by the short embolus and simple median apophysis (Fig. 1).

Male.—Total length 4.79 mm. Carapace 2.40 mm long, 1.87 mm wide. Leg spination: femora: I r1-2-1; IV r0-1-1; tibiae: I, II v1r-4-2, r0-1-1; metatarsus II r1-1-2. Leg measurements in mm:

	I	II	III	IV
Femur	3.49	3.53	2.99	3.55
Patella	0.95	0.94	0.83	0.83
Tibia	3.35	3.31	2.63	3.38
Metatarsus	3.44	3.42	2.92	4.09
Tarsus	<u>1.66</u>	<u>1.55</u>	<u>1.15</u>	<u>1.55</u>
Total	12.89	12.75	10.52	13.40

Palpal bulb with large subtegulum, hook-like median apophysis, terminal embolus expanded just behind its tip (visible anteriorly), and membranous conductor (Figs. 1, 2).

Female.—Total length 5.75 mm. Carapace 2.68 mm long, 2.06 mm wide. Leg spination: patella I d0-0-1; tibiae: III v2-2-0; IV v1p-1p-1p; metatarsus II p0-1-2. Leg measurements in mm:

	I	II	III	IV
Femur	3.35	3.49	3.02	3.67
Patella	1.04	1.01	0.90	0.90
Tibia	2.84	2.77	2.38	3.15
Metatarsus	2.74	2.74	2.56	3.71
Tarsus	<u>1.33</u>	<u>1.22</u>	<u>1.17</u>	<u>1.30</u>
Total	11.30	11.23	10.03	12.73

Epigynum with sinuous lateral margins nearly meeting at middle anteriorly (Fig. 3). Spermathecae with long fertilization ducts and short lateral lobes (Fig. 4).

Material Examined.—PANAMA: *Canal Zone*: Barro Colorado Island, August 1928 (A. M. Chickering, AMNH), 2 males. COLOMBIA: *Valle del Cauca*: near Lago Calima, elevation 1400 m, June 1976 (W. G. Eberhard, MCZ, AMNH), 1 male, 2 females. PERU: *Amazonas*: Montenegro, Bagua, elevation 350 m, 29 September-1 October 1963 (A. Herrer and P. Wygodzinsky, AMNH), 1 male.

Barrisca kochalkai, new species

Figs. 5, 6

Type.—Female holotype from large epiphytic bromeliads at San Pedro, elevation 960 m, Sierra Nevada de Santa Marta, Magdalena, Colombia (18 May 1975, J. A. Kochalka), deposited in AMNH courtesy of Mr. Kochalka.

Etymology.—Named for J. A. Kochalka.

Diagnosis.—Female of *B. kochalkai* may be distinguished from those of *B. nannella* by the epigynal margins being restricted to the sides of the epigynum (Fig. 5), and from the sympatric species *Rhoicinus wapleri* Simon by the ventrally situated epigynal openings.

Male.—Unknown.

Female.—Total length 7.27 mm. Carapace 3.23 mm long, 2.50 mm wide. Leg spination: femora: I d1-2-1; r1-1-1; III d1-2-1; patellae: III, IV p0-1-0; tibiae: I v1r-4-1p; III v1p-2-1p. Leg measurements in mm:

	I	II	III	IV
Femur	3.67	3.67	3.20	3.85
Patella	1.30	1.22	1.04	1.12
Tibia	3.08	3.02	2.51	3.33
Metatarsus	2.95	2.95	2.59	3.82
Tarsus	<u>1.51</u>	<u>1.46</u>	<u>1.30</u>	<u>1.51</u>
Total	12.51	12.32	10.64	13.63

Epigynal margins restricted to sides of epigynum (Fig. 5). Spermathecae with short fertilization ducts and long lateral lobes (Fig. 6).

Material Examined.—COLOMBIA: *Magdalena*: San Pedro, Sierra Nevada de Santa Marta, large epiphytic bromeliads, elevation 960 m, 18 May 1975 (J. A. Kochalka, AMNH, JAK), 2 females. VENEZUELA: *Aragua*: Rancho Grande (Charles T. Collins, AMNH, MCZ), 2 females.

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A COMPARISON OF THE SPIDERS OF THREE CONIFEROUS TREE SPECIES

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ABSTRACT

Composition of the arboreal spider community of three coniferous tree species (red pine, white spruce, and white cedar) was studied in northern Minnesota. The number of species of spiders found on each tree species was similar (22-25 spp.), although there was low similarity of species composition between trees. Numbers of adult individuals varied greatly between trees.

Each tree species contained approximately the same proportions of web building and hunting spiders, indicating some basic resource similarity of the trees. Significant differences in composition of hunting spiders and web-building spiders at the family level were found. The importance of vegetative structure in determining the composition of each group is discussed relative to structural differences of the trees and aspects of the natural history of the spiders.

INTRODUCTION

There are suggestions in the literature that the structure and composition of a spider community depends less on the herbivore population on which it preys than it does on the physical form of the vegetation (physiognomy). Luczak (1963) compared eight stands of pines which differed in age, density and presence of other plants. The stands were found to constitute three phytosociological habitats, yet the same assemblage of orb weavers was found on all eight stands. Barnes and Barnes (1955) found that spider communities in widely separated stands of broomsedge exhibit a high degree of constancy

in structure and composition. The Barnes' and Luczak both suggest that there is a relationship between the structure of plant communities and the communities of spiders that inhabit them. Riechert and Reeder (1970) observed associations between spiders and certain plant species, in a study on the effect of prairie fires on spider distribution. They attributed these associations to structural characteristics of the plants. Duffey (1966, 1970) has shown that habitat structure plays an important role in limiting the distribution of some spider species, both by providing sites of particular architecture or by influencing micro-climate. Likewise, Cherrett (1964) noted that small variations in physical factors within a habitat are associated with significant changes in the spider species present and their density.

A component community (Root 1973) is an assemblage of species associated with a particular resource and is thus a well integrated, coevolved system. Component communities may be associated with plant taxa, e.g., a tree species, or with a microhabitat, e.g., leaf litter or tree holes. Spiders are known to play an important role in a variety of component communities as predatory arthropods. For this reason studies of the spider fauna of various economically important tree species have been made (Allen et. al. 1970, Bosworth et. al. 1971, Chant 1956, Coppel et. al. 1963, Dondale 1956, 1958, 1961, Fichter 1939, Hukusima 1961, Jennings 1976, Legner and Oatman 1964, Loughton et. al. 1963, Luczak 1963, Peck et. al. 1971, Putman 1967, Renault and Miller 1972, Specht and Dondale 1960, Turnbull 1956, 1960, Uetz and Dillery 1969, Warren et. al. 1967).

We pursued the question of the effect of vegetation structure on communities of spiders by comparing the spider fauna on three species of coniferous trees common in Northern Minnesota. The tree species were red pine (*Pinus resinosa* Ait.), white spruce (*Picea glauca* (Moench)), and white cedar (*Thuja occidentalis* L.), and were chosen for the study because they differ in physical structure.

METHODS

The study was completed at the Field Biology Station of the Associated Colleges of the Midwest between July and August, 1975. The station was located on Basswood Lake in the Boundary Waters Canoe Area (BWCA) in northeastern Minnesota. The forest in this area is predominantly coniferous. The three species of trees were all common in the immediate area of the field station, but they differed in exact location as well as in age and size representation. The white cedar was most common on the islands in Basswood Lake, and was represented primarily by mature trees. White spruce was common inland in large stands. Red pine was also common inland. Data were collected from immature trees located in small planted stands near the station.

Collections were made with a sweep net, and were made only from branches within reach of the ground (max. 1.5 m). The branches were placed within the sweep net and shaken vigorously. The net was then emptied onto a small ground cloth and the spiders were caught and placed in vials of 75% ethanol. A total of 30 minutes collecting with the sweep net was spent on each tree species. No spiders were collected from the trunk region. There was no attempt to test the adequacy of this sample size. There was also no attempt to determine site variance, seasonal variance, or variance between trees of the same species. Future research should account for these variables.

The spiders were separated to adults and immatures and identified to family and where possible, identified to genus and species. Spiders that could not be identified to

species were separated and counted as morpho-species. The criterion for morpho-species was general appearance (not genitalia). Adult spiders were the basic working unit of all the comparisons made in the study.

Sorensen's Similarity Quotient (QS) (Sorensen 1948) was used to determine the degree of similarity of spider faunas collected from the trees: $QS=2C/(A+B)$, where A and B are numbers of species from each sample, and C is the number of species held on common. If QS is less than 50%, the two samples being compared are considered dissimilar (Price 1975).

A second test of similarity, percentage similarity (PS) (Czekanowski 1909, Curtis 1959) was calculated to determine the percentage of spider species held in common between the tree species. The formula is: $PS=2w/(a+b)$, where w=minimum sum of individuals of species held in common between the samples being compared; a and b = the totals of individuals found on the cedar, spruce or pine. No unidentified spider was counted in either the total or the sum of spiders held in common.

RESULTS

A total of 577 adults were collected, representing 9 families, 36 genera and at least 38 species. A species list is given in Appendix 1. The number of species of spiders found on each tree species was fairly constant, while the number of adult individuals varied greatly between tree species. The spruce had both the highest number of species and the highest number of individuals.

Spider composition was compared according to method of prey capture, with hunting spiders comprising one group and web building spiders comprising a second (Figure 1). The same relative composition of each group was found on each of the tree species. The

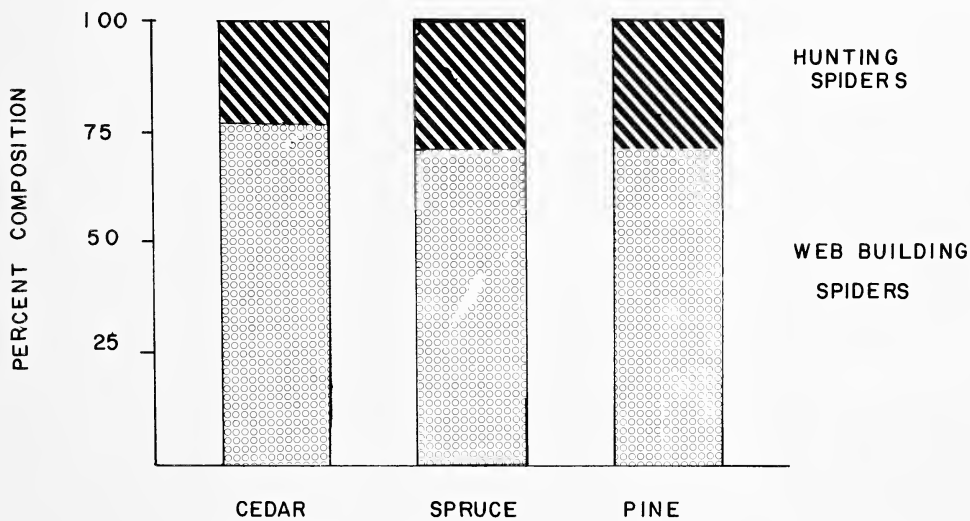


Fig. 1.—Composition of spiders by foraging strategy on three tree species in the BWCA, Minn. The two groups, web building spiders and hunting spiders, represent the major foraging strategies of spiders.

Table 1.—Number of adult spiders and number of spider species collected from three tree species found in the BWCA, Minn.

	Cedar	TREE SPECIES		Total
		Spruce	Pine	
Total Number of Individuals (Adults)	133	267	177	578
Number of species	22	25	24	41

web building group made up 74.6%, 74.3% and 79.7% for pine, spruce, and cedar, respectively. To test significance of differences in relative composition between tree species, a test of independence for R X C contingency tables was used (G-test; Sokal and Rohlf 1969).

Relative composition of the groups representing the two major spider foraging strategies (web building and hunting spiders) is not significantly different between tree species (Figure 1) ($G=1.622; 0.1 < p < 0.5$). Although the proportions of the groups are constant for all the trees examined, there are marked differences in the families comprising the groups on each of the tree species. In the web building group, the orb weavers, Araneidae and Tetragnathidae are more numerous on cedar than on spruce (Figure 2). In the pine and spruce, the space web builders are more prominent than the orb weavers. The theridiids, dictynids and linyphiids are termed space web builders, because their webs are three dimensional and fill spaces between structures like needles or branches. Theridiidae (scattered line weavers) and Dictynidae (hackled band weavers) are the predominant space web builders on cedar. The Linyphiidae (sheet line weavers) make up the largest proportion of space webs in the spruce. Tree species has a significant influence on the relative composition of spiders ($G=85.623; p < 0.01$) of the web-building group.

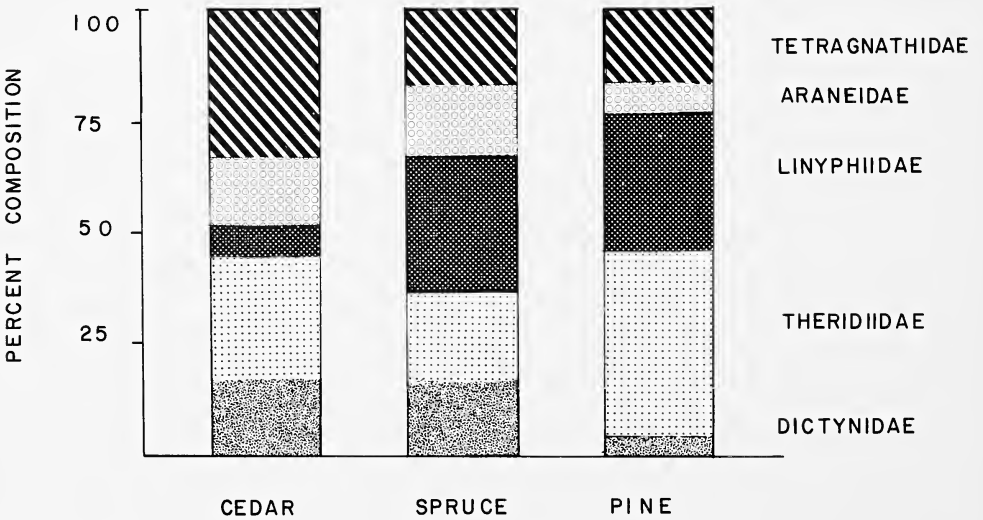


Fig. 2.—Composition of web building spiders by family on each of the three tree species.

Table 2.—Two indices of similarity: 1) Similarity quotient (QS), species similarity based on presence or absence of species (Sorensen 1948) and 2) Percentage Similarity (PS), based on relative abundance of species held in common (Curtis 1959), calculated for spider faunas on the three tree species.

	Pine and Spruce		Pine and Cedar		Spruce and Cedar	
	QS	PS	QS	PS	QS	PS
Hunting Spiders	0.66	0.51	0.54	0.39	0.41	0.32
Web Building Spiders	0.63	0.48	0.31	0.45	0.42	0.49
All Spiders	0.65	0.48	0.43	0.44	0.41	0.55

The hunting spider group (Figure 3) contains the families Salticidae (jumping spiders) and Thomisidae (crab spiders). Hunting spider composition of the cedar and spruce was similar; though Salticidae were less well represented on red pine. These differences were of marginal significance ($G=8.843$; $0.1>p>0.05$).

There is a higher similarity quotient (QS) for all three groupings of spiders found on pine and spruce than on pine and cedar or on spruce and cedar (Table 2). The lowest similarity quotient was found comparing the web building spiders on pine and cedar. The percentage similarity (PS) showed the same trend (higher similarity on pine and spruce) for the hunting spiders only. Interestingly, while the web building spiders showed variable similarity quotients (0.31 to 0.63), the percentage similarity was fairly constant (0.45 to 0.48).

DISCUSSION

Although the community of spiders of each tree is different, the relative composition of groups of spiders (defined by their method of prey capture) appears to be similar from

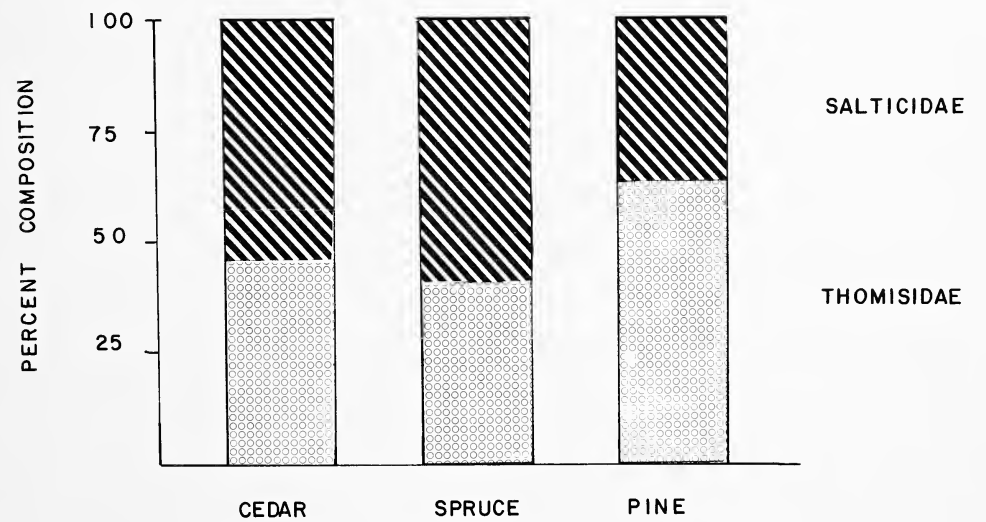


Fig. 3.—Composition of hunting spiders by family on each of the three tree species.

one tree type to the next. Similar ecological roles—predation by active hunting or predation by construction of webs—may be taken by different families on different trees. The similarity in proportions of wandering spiders and web building spiders may imply some basic resource similarity of the trees. However, the differences in the relative composition of families implies that there may be subtle differences in the trees which influence spiders at the family level. Web building spider families differ in web type, while hunting spiders may differ in foraging behavior. Many of the differences seen in the composition of spiders on the three conifers might then be explained by structural differences of the trees and aspects of the natural history of each group.

The dominance of the space web group (Linyphiidae and Theridiidae) on the pine and spruce could be explained by the structure of needles and branches. There are numerous spaces in the spruce that such webs could fill. The Dictynidae are small space web builders and were relatively more abundant on both the cedar and spruce. Their webs fill the spaces between the needles of the spruce and between the ends of the overlapping needles of the cedar branches. Red pine does not provide a suitable structure for their webs as the needles are divergent and very flexible.

The orb weavers, a large portion of which are tetragnathids, are predominant on white cedar. Tetragnathid webs tend to be oriented at an angle or nearly horizontal and are commonly found near water (Kaston 1972). These two characteristics might affect the web building site preference of these spiders. Branches of cedars tend to hang down or droop, leaving large areas beneath the branches for horizontal webs. The cedar trees were most common on the smaller islands and were close to the waters edge. The higher humidity of these sites might favor tetragnathids, as suggested by Cherrett (1964).

Hunting spiders are not as likely to be dependent on tree structure, as they do not build webs. However, differences in the hunting spider fauna on different trees do exist (Figure 3) and the structure of the tree may be important. The greater relative abundance of thomisids on the red pine might be explained by the structural characteristics of the needles. The red pine needles are flexible and are in clusters of two. They might not provide sufficient support for the larger salticid spiders who need a solid platform from which to jump. Also, the clustering of the needles could provide a suitable hiding place for the thomisids, who tend to "sit and wait" for their prey.

Lower similarity index values indicate that the spider fauna of cedar is the most unique of the three trees examined. The cedar has the most distinctive needle structure of the three tree species. It also differs the most in location from the other trees, which in turn could affect many important variables: microclimate, rates of immigration and emigration and mortality.

The differences between patterns shown by the two similarity indices reflect differences in the indices themselves. The presence or absence of species is included in calculation of QS, while relative abundance of species is included in the PS index. It is unclear why there should be a different pattern for web building spiders in the PS index and not hunting spiders.

These examples fit the categories that Turnbull (1973) suggested as how the structure of vegetation could influence the spider fauna: (1) the architectural characteristics of some plants could suit the behavioral patterns of some spiders, (2) the plant formation could provide favorable or unfavorable microclimatic factors. This study exemplifies the first category suggested by Turnbull; data are not available to test the second. There are likely to be several important microclimatic variables that might be influenced by tree structure. For example, wind speed, air temperature, and humidity could all potentially

affect spider species composition. Despite a lack of microclimate data, we believe that our data strongly suggest that vegetative structure is important in determining the composition of the arboreal spider community.

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APPENDIX I

List of Genera and Species and Numbers of Adults.

Hunting Spiders				Web-Building Spiders			
	Pine	Spruce	Cedar		Pine	Spruce	Cedar
Family Salticidae	16	37	14	Family Tetragnathidae	20	32	40
<i>Zygoballus</i> sp.	1			<i>Teragnatha</i> sp.	20	32	40
<i>Eris</i> sp.	1	7	3	Family Araneidae	9	32	15
<i>Sassacus</i> sp.		1		<i>Mangora</i> sp.			1
<i>Agassa</i> sp.		2		<i>Araniella displicata</i> Hentz		1	
<i>Thiodina</i> sp.		2	4	<i>Zygiella</i> sp.		2	12
<i>Phidippus</i> sp.	4	3		<i>Metepeira</i> sp.			2
<i>Metacryba</i> sp.	3	1		Unidentified	9	29	
<i>Sarinda</i> sp.			2	Family Linyphiidae	42	60	7
<i>Metaphidippus</i> sp.			2	<i>Frontinella</i> sp.	6	11	
<i>Ballus youngii</i> Peckham			2	<i>F. pyramitela</i> (Walckenaer)	3	20	
<i>Icius</i> sp.			1	<i>Pityohyphantes</i> sp.		1	
<i>Phlegra</i> sp.		6		<i>P. costatus</i> (Hentz)	2		
Unidentified	7	15		<i>Bathyphantes</i> sp.	5		
Family Thomisidae	27	26	12	<i>Drapetisca</i> sp.	26		3
<i>Tmarus</i> sp.	2	3		Unidentified		28	4
<i>Coriarachne</i> sp.	5	1	2	Family Theridiidae	59	41	29
<i>Misumenoides</i> sp.	8	12	7	<i>Achaearanea</i> sp.			1
<i>Ozyptila</i> sp.	2	5		<i>Ctenium</i> sp.	7		2
<i>Xysticus</i> sp.		1		<i>Theridion</i> sp.	45	25	26
<i>Thanatus</i> sp.			2	<i>Anelosimus</i> sp.	7	16	
Unidentified	10	4	1	Family Dictynidae	2	34	15
Family Gnaphosidae	1			<i>Dictyna</i> sp.	2	34	15
<i>Drassyllus</i> sp.	1						
Family Clubionidae	1	5	1				
Unknown	1	5	1				

RESEARCH NOTES

A NEW SPECIES OF *EBO* FROM NORTH-CENTRAL TEXAS
(ARANEIDA: PHILODROMIDAE)

During a study of the Thomisidae and Philodromidae of Wichita County, Texas, a new species of *Ebo* was discovered. The new species, *Ebo redneri* is a member of the subgenus *Titanebo*. The description format follows that used in a recent revision of the genus (Sauer, R. J. and N. I. Platnick, 1972. Canadian Ent. 104:35-60). Definitions of anatomical terms and indexes can be found in Sauer and Platnick (1972) and Schick (1965. Bull. Am. Mus. Nat. Hist. 129:1-180). All descriptions and measurements are based upon entire type series. Measurements are given by mean followed by standard deviation, in mm. A special thanks is extended to Dr. B. J. Kaston, who kindly donated the Carpenter material to Midwestern State University, and Drs. C. D. Dondale, D. T. Jennings and Mr. J. H. Redner for their critical reviews of the manuscript and helpful suggestions.

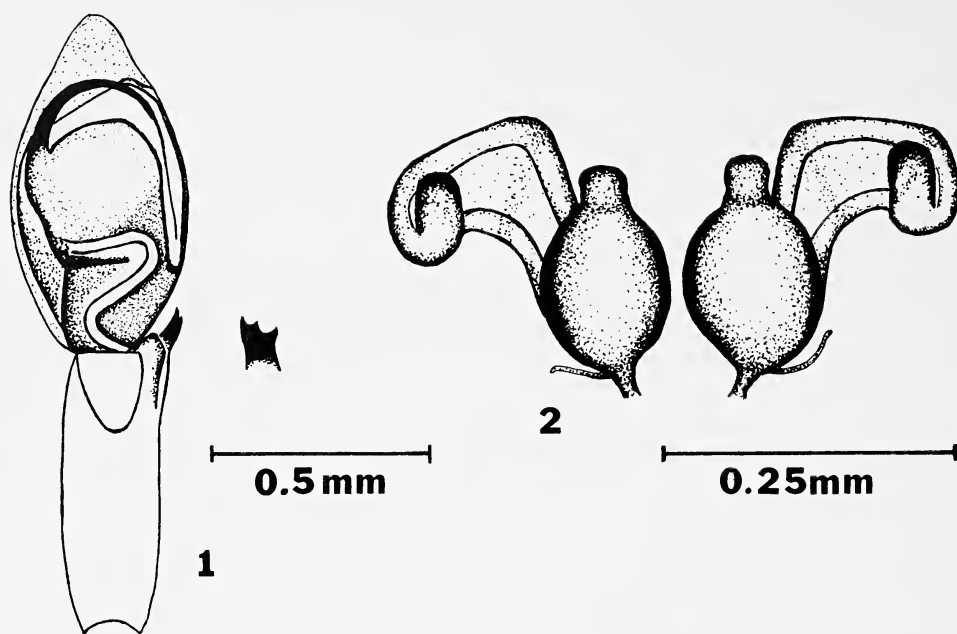
Ebo (*Titanebo*) *redneri*, new species

Figs. 1-2

Types.—Holotype male and five paratypes (one male and four females) from Goodman Road Pond, NE corner Wichita Falls, Wichita County, Texas, 300m elevation (18 Nov. 1976, J. C. Cokendolpher); deposited in the American Museum of Natural History. Additional paratypes, deposited in the Invertebrate Collection at Midwestern State University. TEXAS: Archer County; one female (23 Feb. 1973, H. Horry). Wichita County: one male (Hicks); 2 km S. Burkburnett, one female (16 Sept. 1976, J. C. Cokendolpher); Wichita Falls, one female (29 Dec. 1976, J. C. Cokendolpher and K. Douglass); Lake Wichita, three males (16 Sept. 1967, R. M. Carpenter), six males and ten females (1 Oct. 1967, R. M. Carpenter).

Etymology.—This species is named in honor of J. H. Redner of the Biosystematics Research Institute, Ottawa, Canada, in recognition of his work on the Philodromidae and his assistance in the determinations of crab spiders from Wichita County, Texas.

Male.—Total length 3.84 ± 0.26 ; cephalothorax length 1.69 ± 0.05 , width 1.74 ± 0.10 ; femur II length 3.64 ± 0.14 . Cephalothorax light brown, darker marginally; sides evenly covered with black reticulations. Lateral edges of cephalothorax with thin white line, indistinct in some specimens. Cephalothorax with median, light band slightly wider than second eye row; creamy-white, V-shaped maculation enclosed within median band. Eyes dark brown to black, on low, light-brown tubercles flecked with browish-black spots. Clypeus creamy to white. Dorsum of abdomen off-white to yellowish, with extensive brownish-black blotches and few white spots laterally; cardiac mark brownish-black, margined in white; venter off-white with few, indistinct brownish spots. Sternum, labium, palp-coxal lobes and legs light brown with scattered brownish-black spots, these concen-



Figs. 1-2.—*Ebo redneri*, new species: 1, ventral view of left palp with retrolateral view of RTA; 2, spermathecae, dorsal view.

trated on legs to form indistinct bands. Patellae and femora of legs with thin white, to off-white, ring on distal margin. Distal end of coxa with thin white, to off-white, line ventrally. Palpal segments lightened distally.

Palp as in Fig. 1. Embolus of intermediate length, arch broad; conductor length index 6.2-7.0, averaging 6.5. Cymbium pointed distally, one-tenth longer than tibia. Tegulum broadly arched distally. RTA tridentate with teeth directed antieriad or slightly mesad.

Female.—Total length 4.57 ± 0.56 ; cephalothorax length 1.88 ± 0.11 , width 1.87 ± 0.11 ; femur II length 3.30 ± 0.19 . Coloration as in male, but with V-shaped mark on cephalothorax indistinct; cardiac mark with yellowish-white border. Brownish-black blotches on body smaller and less distinct than in male. Palpal segments white distally.

Epigynum typical for subgenus. Spermathecae as in Fig. 2. Intromittent division extending beyond spermathecae anteriorly and far laterad, with the anterior part greatly expanded and with margin horizontal or sloping posteromesad. Spermathecal organ arising on caudal edge of intromittent division, projecting antieriad. Torus directed antero-mesad.

Comments and Diagnosis.—*Ebo redneri* males differ from all other known species of *Ebo*, except *E. texanus* and *E. californicus*, by having a tridentate RTA and a conductor length index of about 6.5. *Ebo redneri* can be distinguished from *E. texanus* by having the palpal tibia shorter than the cymbium, clypeus white, and the shorter length of femur II. *Ebo redneri* differs from *E. californicus* by always having a tridentate RTA and by the distally arched tegulum. Females of *E. redneri* differ from all other known species of *Ebo* by the large and laterally expanded intromittent division of the copulatory tubes, and by the anteriorly directed spermathecal organs. *Ebo redneri* females can also be distinguished from females of *E. creosotis* and *E. andreaannae* by the lack of gold-colored scales on the abdomen.

Mature specimens have been collected from the middle of September to late February. Specimens have been recorded from mesquite trees (*Prosopis juliflora*), where they prefer to stay on outer limbs one to two meters above ground. Three females collected in November deposited egg sacs in the laboratory. One egg sac contained 13 fertile eggs but the second female produced an infertile yolk-like material in which the individual "eggs" appeared to run together. The third female deposited fertile eggs on 20 November, which resulted in nine spiderlings. The spiderlings first left the egg sac on 20 December of the same year.

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THERIDION BIMACULATUM (LINNÉ) IN VERMONT (ARANEAE : THERIDIIDAE)

In 1975, six specimens of the European spider *Theridion bimaculatum* (Linné) were collected by Mark E. Whalon in the Meserole Apple Orchard, Colchester, Vermont, U.S.A. These specimens were collected by sweep-netting in grass and other low vegetation immediately beneath apple trees. Deposited in the University of Vermont Museum of Zoology are one male 5 June 1975, and two males and one female 9 June 1975. Deposited in the Harvard Museum of Comparative Zoology are one male and one female 19 June 1975. This species was previously known in North America only from Washington and British Colombia (Levi and Randolph 1975:43).

When *Theridion* was revised for North America (Levi 1957, 1963), *bimaculatum* was not included in the genus. A good description of this species is found in Levi (1956:407-412). The male can be easily recognized by the spur at the base of femur IV, the central tubercle on the sternum, and the shape of the palpal cymbium. The female has a distinctly protruding epigynum, similar to that of *Theridion neomexicanum* Banks (Levi 1957:76, fig. 269) and *Thymoites unimaculatus* (Emerton) (Levi 1957:108, fig. 409; Levi and Randolph 1975:47). The female of *T. bimaculatum* could easily be misidentified as either of these two species, but differs from both of them in having a small depression in the anterior facing surface of the epigynum. The color patterns and the shape of the clypeus are also useful characters for distinguishing these species from each other.

There is a typographical error in Levi (1956:409). Where it says, "The male, however, lacks the . . .", it should say, "The female, . . .". In Levi and Randolph (1975:43) the name of *T. bimaculatum* is misspelled, "*bimaculata*".

This research was supported by the Hatch Fund, from the Vermont Agriculture Experiment Station, through Dr. Bruce L. Parker, Dept. of Entomology, Univ. of Vermont. Dr. Herbert W. Levi confirmed the identifications and read the manuscript.

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**A NEW SPECIES OF *MAZAX* FROM TEXAS
(ARANEAE: CLUBIONIDAE)**

Through the generosity of Timonthy C. Kaspar (Iowa Park High School, Iowa Park, Texas) I had the opportunity to examine spiders he collected in Texas and México. Among the material was a form which is described as new in the present paper. The description format follows that in a recent revision of the genus (Reiskind, J. 1969. Bull. Mus. Comp. Zool. 138: 162-325). A special thanks is extended to Drs. Norman I. Platnick and Jonathan Reiskind for their critical review of the manuscript and helpful suggestions.

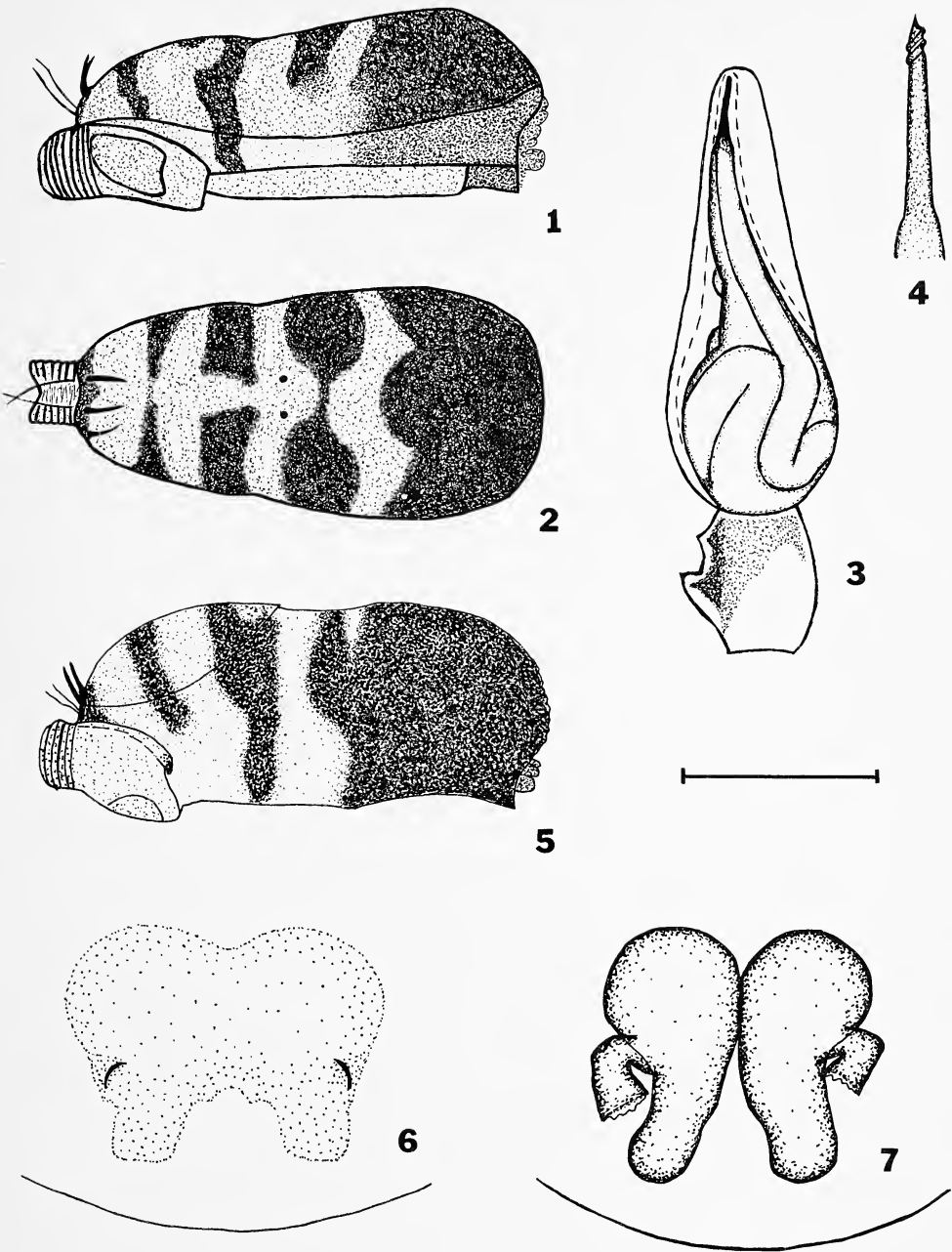
Mazax kaspari, new species

Figs. 1-7

Types.—Male holotype and female paratype from 4.0 km W. Lajitas, Presidio Co., Texas, 28 March 1975 (T. C. Kaspar), deposited in the American Museum of Natural History. The specific name is in honor of Mr. T. C. Kaspar, who collected the type specimens.

Male.—Carapace length 2.14 mm; carapace width 1.38 mm; sternum length 1.13 mm; sternum width 0.81 mm; femur IV length 2.00 mm; femur IV width 0.39 mm; abdomen length 2.63 mm; abdomen width 1.20 mm; petiole length 0.20 mm; embolus length 0.13 mm; bulb length 0.75 mm.

Carapace light orangish-brown with fine granulate surface; cephalic region and margins darker, with few thin, short hairs and few long setae. Eyes large, equal (except anterior median eyes smaller than others), bordered in black; anterior row slightly recurved, posterior row straight. Carapace narrower in head region, smoothly truncated anteriorly. Thoracic groove moderate. Abdomen elongate, with short anterior rugose petiole, slightly constricted in middle, covered with full, lightly granulose, reddish-brown dorsal sclerite (Fig. 1). Sclerite with broken bands of white, plumose hairs at constriction and anterior to constriction. Whole dorsum covered with sparse, simple hairs. Posterior one third of dorsum brownish-black with four irregular, brownish-black bands anteriorly (Fig. 2).



Figs. 1-7.—*Mazax kaspari*, new species: 1, male abdomen, lateral view; 2, male abdomen, dorsal view; 3, right palp, ventral view; 4, embolus, ventral view; 5, female abdomen, lateral view; 6, epigynum, ventral view; 7, spermathecae, dorsal view. (Scale line = 1.0 mm for Figs. 1 and 2; 0.35 mm for Fig. 3; 0.10 mm for Fig. 4; 1.20 mm for Fig. 5; 0.30 mm for Figs. 6 and 7).

Epigastric sclerite (forming petiole anteriorly) and almost full ventral sclerite light reddish-brown. Inframammillary sclerite dark red-brown. Three heavy spines (two medial, one lateral) set on low tubercles, and two long abdominal setae at anterior of abdomen (just posterior to petiole, with spines posterior to setae). Sternum yellowish-brown, with few hair-like, long setae. Pedicel short. Ground-color of chelicerae orange-brown, with brown reticulations; two moderate retromarginal teeth and two promarginal teeth; distal teeth large than proximal; distal promarginal teeth larger than distal retromarginal teeth. Fang furrow densely scopulate on margins, heaviest on promargin. Coxae and trochanters yellow-brown, darker laterally. Trochanter IV notch moderate. All leg segments yellow-brown; sides of femora I-III dark reddish-brown, patella I and II with reddish-brown spot on mesial margin, tibia III and IV with sides reddish-brown, metatarsus IV with two, wide, lateral bands of reddish-brown. Legs lightly hirsute. Tibia I (right) ventral spination: 3-2, moderately strong and long; leg I (left) missing. Pedipalp with long, cusp-like tibial apophysis, with two points (Fig. 3). Tarsus with globose genital bulb drawn out into long neck with fairly long, strong, straight, and sclerotized embolus with terminal double twist (Figs. 3, 4).

Female.—Carapace length 2.70 mm; carapace width 1.59 mm; sternum length 1.23 mm; sternum width 0.96 mm; femur IV length 2.39 mm; femur IV width 0.48 mm; abdomen length 3.19 mm; abdomen width 1.81 mm; dorsal sclerite length 1.44 mm; dorsal sclerite width 1.13 mm; petiole length 0.18 mm.

Carapace and eyes as in male, but with head region wider. Abdomen elongate, with short anterior rugose petiole; slightly constricted in middle; moderate orange-brown, lightly granulose, dorsal sclerite anterior to constriction (Fig. 5). Dorsum with pattern of four brownish-black horizontal bands and brownish-black posterior as in male, except base coloring off-white. Venter off-white anteriorly, brownish-black posteriorly. Epigastric sclerite light, orange-brown. Inframammillary sclerite very dark red-brown. Two moderate spines set on low tubercles and two long abdominal setae at anterior of abdomen (just posterior to petiole, with spines posterior to setae). Sternum, pedicel, chelicerae and dentation of chelicerae as in male. All leg segments colored as in male, trochanter IV notch moderate. Tibia I ventral spination: 3-3, moderately strong and long.

External epigynum with two small, widely separated openings (Fig. 6). Internal structure with globose spermathecae drawn out into moderately thin posterior necks and thickened bursa copulatrix (Fig. 7).

Diagnosis.—*Mazax kaspari* differs from all known *Mazax*, except *M. pax*, by the ventral spination of the first tibia (3-3). *Mazax kaspari* can be distinguished from *M. pax* by the lack of white plumose hairs on the carapace, the long double twisted embolus and the thickened bursa copulatrix.

Remarks.—This species is intermediate between the *ajax* and *pax* species groups. Although probably deserving a separate group, I feel it best to leave *Mazax kaspari* unplaced until a thorough revision of the South American forms of this genus is made. The groups as presently understood are not well defined on the basis of genitalia.

Natural History.—The only known specimens were captured on grasses along the bank of the Río Grande. The slender morphology of this species suggest it is an ant mimic, but this has not been verified in living specimens.

Distribution.—Known only from the type locality.

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Eastern section:

Dr. Allan R. Brady (host)
Biology Department
Hope College
Holland, Michigan 49423
Dates: 20-23 June 1979

Western section:

Dr. Norman V. Horner (host)
Biology Department
Midwestern State University
Wichita Falls, Texas 76308
Dates: 14-16 June 1979

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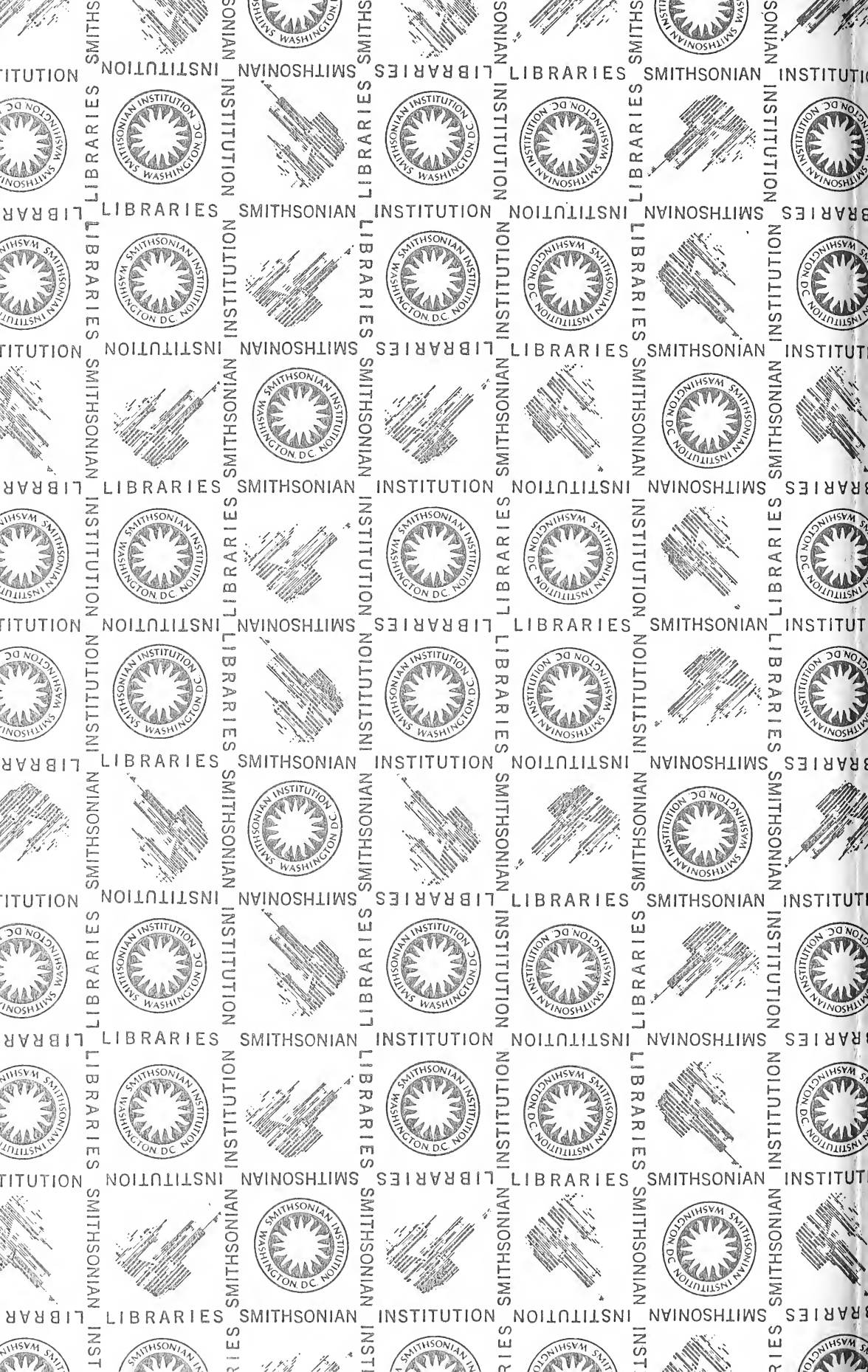
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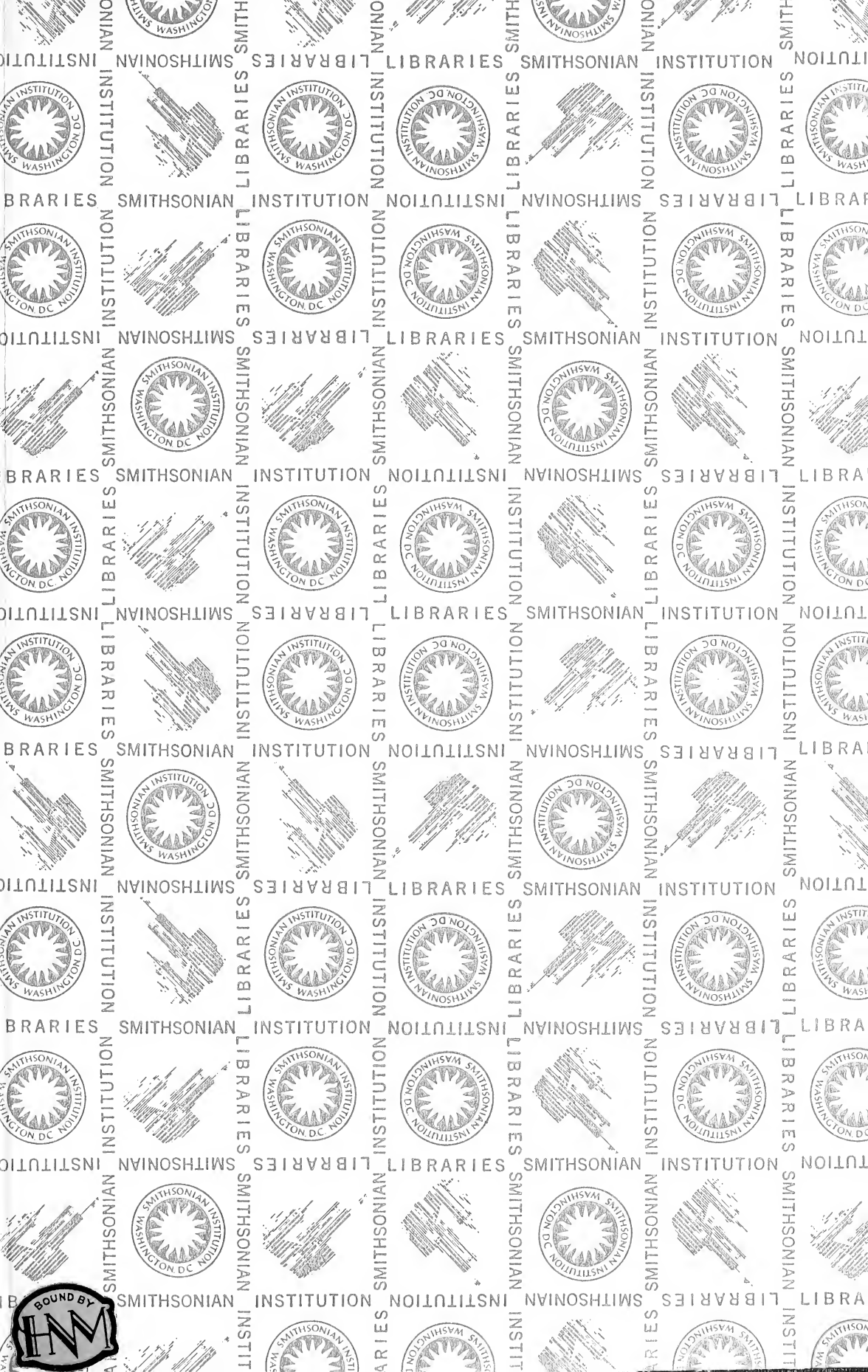
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Cover illustration, *Stygnoplus* sp. (Opiliones, Stygnidae), by William A. Shear

Printed by The Texas Tech Press, Lubbock, Texas

Posted at Warrensburg, Missouri, U.S.A., January 1979





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